INDEXED.

# International Marine Engineering

JANUARY, 1911.

MI8

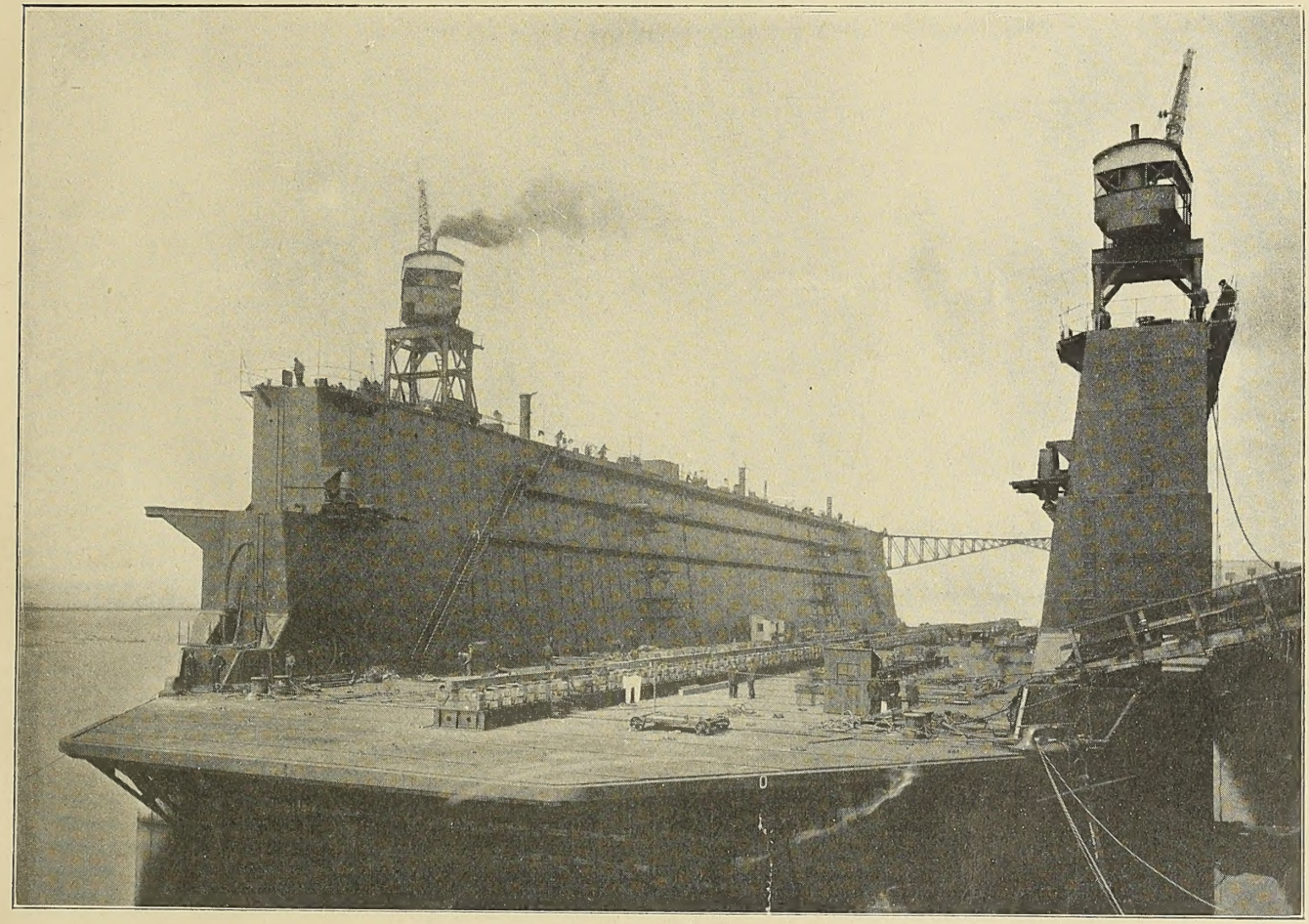
LIBRARY JAN 9 1911

## A 22,000-TON FLOATING DRY DOCK FOR BRAZIL.

The Brazilian Government has recently received delivery at Rio de Janerio of the new 22,000-ton floating dock built by Messrs. Vickers, Sons & Maxim, Limited, of Barrow-in-Furness. This dock is intended for accomodating the *Minas Geraes* and *Sao Paulo*, the two super-Dreadnoughts lately built for Brazil by Sir W. G. Armstrong, Whitworth & Co., Limited, of Elswick-on-Tyne, and Messrs. Vickers, Sons & Maxim, Limited, of Barrow-in-Furness, and it will be moored in the entrance channel between Governador Island and Boqueira Island, the Brazilian naval store yard at Rio de Janiero.

The dock is of the double-sided, self-docking type known as

| | Ft. | Ins. |
|---|---|---|
| Over-all length of dock over 25-foot platform | 550 | 6 |
| Over-all length of dock over pontoons | 500 | 6½ |
| Over-all length of central section | 165 | 3 |
| Over-all length of each end section | 167 | 7¾ |
| Over-all width of dock | 136 | 0⅝ |
| Over-all depth of pontoon at center | 18 | 3¾ |
| Over-all depth of pontoon at foot of walls | 17 | 9¾ |
| Over-all length of side walls, including docking lands | 450 | 6 |
| Over-all height of side walls above pontoon deck | 45 | 6 |
| Over-all height of side walls and pontoon | 63 | 3⅝ |
| Over-all width of side walls at base | 18 | 0⅝ |
| Over-all width of side walls at top | 12 | 6½ |
| Clear width | 100 | |
| Maximum draft of vessel | 30 | |
| Height of keel blocks | 4 | |
| Depth of water required to dock vessel of 30-foot draft, including 6 inches for troughs and 5-inch clearance | 53 | 3 |
| Freeboard of side walls | 10 | 6 |



A 22,000-TON FLOATING DRY DOCK BUILT IN ENGLAND AND TOWED TO BRAZIL.

the bolted-sectional type, and has been built from designs prepared by Messrs. Clark & Standfield, consulting engineers, of Westminster, London. It consists of a pontoon, or lifting portion, and two parallel side walls, built on to, and forming part of, the same, and the whole is divided lengthwise into three sections of unequal length by vertical joints running round the whole profile of the dock. The following is a table of some of the leading dimensions:

The pontoon consists of a rectangular structure plated in all round, with the exception of the portion of the deck which comes directly under the walls, and stiffened internally by longitudinal and transverse girders. It is divided into three sections by two joint chambers. The middle section is 165 feet 3 inches long, and rectangular in plan, and the two end sections are each 167 feet 7¾ inches long, and have their outer extremities built in the form of a point or bow, terminating in

a working platform, carried on strong plate and braced girders.

The general construction of all three sections is, however, the same. The bottom plating runs transversely in the home and rider strakes, and is lap-jointed. The top or deck plating is similar, but here there are end butt joints with inside covers. The sides of the pontoons are formed by the back plating of the walls. The pontoon is divided into six compartments by five longitudinal watertight plate bulkheads, occurring one at the center or keel line, and the others (called the inner, intermediate, and outer intermediate bulkheads) on each side of the center. These bulkheads are of varying heights to suit the camber of the deck of the pontoon. The deck of the pontoon is built with a camber. The central portion under the keel blocks is flat for a width of 10 feet thus affording a parallel base for the keel blocks. Outside, the plating cambers off until at its junction with the wall it is 6 inches lower than at the center. Transversely the pontoons are divided (in addition to the joint chambers) into fifty bays, sixteen in the central section and seventeen in each end section, by transverse girders. The end bay in the points is 5 feet long, but all the others are 10 feet long. The walls of the dock are rectangular structures in plan, but they have a batter to the face or inside. They are in two tiers or stores, and are situated on the top of the pontoons, of which they form a continuation.

At a distance of 20 feet below the top deck is the engine-deck, which is continuous over the whole length of the side walls. On this deck are placed the boilers, engines, dynamos, and machinery, the various rooms containing these being divided off by partition bulkheads. Above the same deck the necessary accommodation for the crew of the ship is provided. The engine-deck, which is longitudinally plated and single riveted throughout, is attached to the side plating by an angle ring, and is watertight over its whole length. Each wall is divided, in addition to the joint chambers, into twelve watertight divisions by plate bulkheads coming in line with the bulkheads in the pontoon, of which they are a continuation. These extend to the height of the engine deck, and are plated transversely, and single riveted throughout. In each end section of the dock the engine-deck is divided off by watertight collision bulkhead, being a continuation of the first watertight bulkhead in the side wall. The engine-deck of the end sections is further divided by three non-watertight partition bulkheads, a doorway being provided to give access from one room to another. The upper portion of one of these bulkheads is made watertight to form an end to the water tank. Each wall of the central section is divided by similar partition bulkheads. The joint bulkheads of all sections are made watertight, and provided with a watertight door at the engine-deck level to give access from one section to another.

About 1 foot below the top deck an iron running deck extends from ladder to ladder, as shown on the general view of the dock, consisting of chequered plate and an edging angle, and carrying on its outer edge a rubbing timber supported by brackets projecting from the face plating of the wall. These brackets occur in way of every other side frame. At a distance of about 8 feet 6 inches and 19 feet, respectively, below this, two further stages, known respectively as painting and shoring stages, are provided. They are of similar construction to the running deck. The running deck is provided for enabling ropes to be easily handled and run from one end of the dock to the other outside the stanchions. On it are placed the timber heads, fairleads to capstans, and such fittings as are required in berthing the vessel.

The berthing stage is chiefly fitted for slinging stages from it to the vessel for the purpose of painting, and to a moderate extent it might be used as a shoring stage. The shoring stage, which occurs at the level of the engine deck, is specially stiffened and built for the purpose of shoring up the sides of the vessel by means of horizontal shores, a timber walling being provided along the face of the wall, against which the heel of the shores may be wedged up.

In close proximity to each boiler a coal bunker is fitted into the engine room, and a fresh water tank, of a capacity of about ten tons, is likewise provided in the wall close up to each boiler. The space in the upper chambers of the side wall above the engine deck, which is not utilized for the main or auxiliary machinery of the dock, has been fitted up for the accommodation of a crew of 600 men and 70 officers, as far as regards their sanitary requirements and the cooking of their necessary food.

Both ends of the central section and the square ends of the terminal sections are provided with a joint chamber and joint, by means of which the sections can be joined together or parted. The length of the joint chamber is 5 feet 3 inches center to center of the joint bulkhead plate. This length is equally divided over the two sections. These sections are stiffened, top and bottom, by means of lugs and gussets falling in line with the frames on the joint bulkhead, and by a continuation of the longitudinal bulkheads. The actual joint across the bottom and up the sides is by means of angles, riveted to the bottom and side plating by a zig-zag pitch of rivets. Over this portion the plating is doubled, the doubling plate being flush with the joint angle, and extending back as far as the first rider plate, but the plating itself on the central section is ¾ inches short of this, to form a recess into which a rubber or other compressible ring may be inserted, and which, when pressed against the flat face of the half of the joint chamber, makes a watertight joint. The joint angle is pierced by holes to take the joint bolts which connect the two sections together. The joint above the angle across the pontoon deck, and up the sides of the wall to the level of the top strake of the side plating, is formed by a single cover-plate, bolted or riveted to the skin plating, watertightness being obtained by means of a canvas or felt strip. The joint over the top strake of plates is similar, but it has double covers. Across the top deck the deck plate is doubled, and the joint made with double covers. In way of the intermediate and longitudinal bulkheads of the pontoon a further connection is made by prolonging those bulkheads into the joint chamber, the two being joined by a single cover plate.

The hull of the dock has been constructed throughout of mild Siemens-Martin steel of the quality used in shipbuilding under Lloyd's rules, and all the plates were punched in a multiple punching machine, whereby the absolute accuracy and correct distance of every hole, lengthways and crossways, was assured, the design of the dock having been so arranged that all lengths and breadths of plates, positions of butts, frames, and bulkhead rings were multiples of the unit rivet pitch of the dock. All countersunk holes were countersunk to at least three quarters of the thickness of the plate. The rivets throughout the dock consist of ⅞-inch steel rivets, except where the scantlings are under 7/16 inch, in which case ¾-inch rivets have been used. The riveting of the whole of the outside of the pontoon is flush countersunk, the remainder of the work being riveted according to Vickers' general practice, and where non-countersunk work was used the points were carefully set up so as invariably to leave a sufficient quantity of metal outside the hole. The pitch of the rivets on all watertight seams has not exceeded 3 inches, and that on non-watertight seams and frames 6 inch. On the flange of the joint angles attached to the plating where zig-zag riveting was specified the pitch of the rivets was 4½ inches.

The machinery of the dock comprises the boilers, engines, pumping plant, valves, and the valve lifting gear, and everything necessary for the sinking and raising of the dock. There are two identical installations, one situated in the port and the other in the starboard wall. This machinery is capable, when

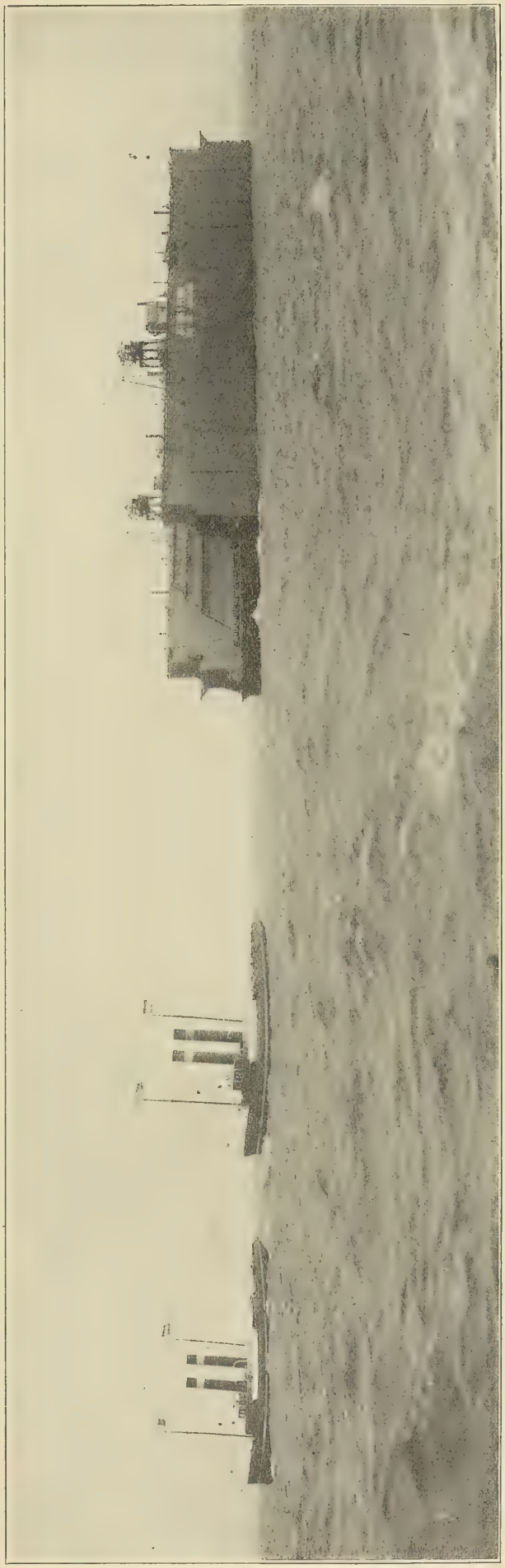
combined, of lifting a vessel drawing 28 feet, and of a displacement not exceeding 22,000 tons, within a period of four hours, counting from the mean of the times when the ship bears on the keelblocks fore and aft, until the pontoon deck at the center of keel line is 7 inches out of the water, due allowance being made for any total stoppage of the machinery for berthing the vessel or other purposes. The plant in each wall consists of three boilers and three engines and pumps—one in each section—sucking from a continuous main drain extending the whole length of the wall. Any one of the three pumps can therefore empty its entire half of the dock.

Each installation consists of three Babcock & Wilcox portable type boilers, each of 909 square feet heating surface and of 150 pounds steam pressure. One spare boiler is provided, making, therefore, seven for the whole dock. The boilers were manufactured at Vickers, Sons & Maxim's Works at Barrow. A feed pump, with connecting piping, is supplied with each boiler and suction piping, leading to the reserve water tank. A branch is provided on the discharge for attaching a hose for washing-down purposes. A 3-inch steel steam pipe extends the full length of each wall with connections, fitted with stop valves to each separate boiler. This steam piping serves all the auxiliary engines, such as capstans, etc., thus allowing any one boiler to be used for this purpose.

The centrifugal pumps are of the "Invincible" type, as manufactured by Gwynnes, Ltd. The suction and delivery pipes are 18 inches diameter. They are each driven directly by a compound non-condensing engine, with cylinders 11 inches and 17 inches by 10 inches, placed at right angles to each other, the engine being placed on its side, and driving direct on to the end of a long vertical shaft, which descends to the pumps at the bottom of the dock. The engines are carried on strong bed-plates, secured to the deck of the engine room, and arrangements have been made to reduce vibration to a minimum, and the interior of the walls in way of the engines has been suitably stiffened. A sensitive high-speed governor controlling the throttle valve is fitted to each engine, and arrangements are made to enable them to be turned by hand. The barring gear is of the self-liberating type. The screw-down regulating valves, opening against the steam pressure, which are fitted to each engine close to the slide valve casing, are worked from the starting position with worm or other suitable gear, so as to prevent jar of the valve and gear when the engines are at work. While the engine cranks are directly attached to the top of the vertical pump shafts, this attachment is not rigid, but allows slight vertical movement, so that the weight of the pump shaft is entirely supported on its own thrust bearings, and does not hang on the engine crankshaft.

Each vertical shaft is supported at intervals in gunmetal-lined plummer blocks attached to the internal framing of the dock. On the upper extremity of these shafts is cottered the upper portion of the ball bearing which carries the weight of the vertical shaft and pump disc. The lower portion of the ball bearing is carried in a casting bolted to the engine deck. The upper portion of the ball bearing is made with a lip to come over the lower portion and prevent dust getting into the races. A watertight gland, which has an extra long sleeve, so as to form a side guide to the shaft, is fitted to the vertical shafts where they pass through the engine deck.

The pumps are seated directly on the top of the main drain running along the bottom of the walls. They take their water entirely from the under side—which is clear of all foot bearings—and discharge it direct at their own level through the skin plating of the wall. Their bodies are of cast iron, carefully finished and specially designed so as to be easily taken apart for the purpose of inspecting or removing the impellers. The bottom of the pump and of the flange of



THE BRAZILIAN DRY DOCK EN ROUTE FOR RIO DE JANEIRO.

the discharge are faced. The impellers are of gunmetal, and they are firmly keyed and pinnned to the spindle, which is of steel. An extra long stuffing box or guide is provided on the top of the pump to ensure steady running, and the end of the spindle terminates in a forged coupling with turned face and socketed for attaching by means of turned bolts to the terminal coupling of the vertical shafts. The pump discharges are in cast iron, with flanges faced and bolted, one end to the discharge valve and one to the skin plating of the dock. The sea end has a projecting lip passing through the plating and fitting into the hole cut therein.

Each discharge is governed by a screw-down sluice valve, placed between the pump delivery flange and the discharge pipe. The body and sluices or gates are in cast iron, and bushed with gunmetal to all moving parts. The lifting screw of the valve is an inside one. The valve spindle is coupled by a deep socket and double-pinned to a solid shaft, which is led up to the top deck, and there furnished with a removable hand wheel. Where the valve rod passes the engine and top decks it is furnished with cast iron stuffing box bushed with gunmetal and a gunmetal gland. A standard is erected on the top deck to steady the rod when being turned, and there is an indicator to show the position of the valve.

The pump discharges are protected by an automatic rubber-faced flap valve making itself tight against the projecting lip of the discharge pipe. The base or seatings of the pumps are bolted directly on to a main drain running the whole length of the walls, and they have been placed as low down as possible, being seated directly on the top of the floors. They are of cast iron of varying diameters, in suitable lengths, with expansion joints and with connection piece between the different sections of the dock.

There are two systems of continuous main drain, one in each wall of the dock. On each system of main drain six flushing inlets—making twelve for the whole dock—branch out of the same. They are in the form of easy bends, standing on top of and bolted to flanges cast on the main drains. These bends are at right angles to the line of the drain and carry a screw-down gunmetal faced valve, similar in every respect to the discharge valves, and the spindles likewise are led up to the top deck. The flushing valves are bolted by flanges to a short length of cast iron pipe passing through the back plating of the wall with a projecting lip, as in the case of the pump discharges. The flushing branch through the back plating is further governed by a flap valve making itself tight against the projecting lip of the discharge pipe. This flap is provided with a lever on its face, so that it can be opened and held open by means of rods and chains running over pulleys attached to a small hand winch with pawl. Each of these flushing inlets is protected by means of a grid, which is of such dimensions as not seriously to obstruct the free flow of water into the flusher.

The branches to which the distributing pipes leading to the different watertight compartments of the dock are bolted are cast on the main drain. Each branch leaves the main drain either in the form of a bend of easy radius or with a well-formed cone. They are provided with a faced and drilled flange at the outer end to receive the distributing valve. The distributing valve attached to each of these flanges is of the direct-lifting type, with double gunmetal ports, held apart by springs and fastened to a gunmetal spindle by a pin of the same material. The body of the valve is of cast iron, gunmetal bushed on the contact surfaces and with gunmetal glands. The valve rods are of galvanized iron pipe, screwed on by means of a socket to the valve spindle and pinned to the same. They are led up through the engine-deck, being fitted with a gunmetal-bushed, watertight gland where passing through this deck. On the other side of the distributing valves, and bolted to them with wrought iron flanges, are the distributing pipes leading to their respective chambers. The ends of these pipes are turned down in their respective troughs. Each separate watertight compartment is fitted with a galvanized wrought iron air pipe led up above the deepest draft line of the dock.

At each corner of the dock, gage or draft boards of timber, painted in figures to show the draft over the keel blocks, are affixed. These are carried on hinges so that they may be swung back out of danger when a ship is entering the dock.

In each section of the dock and on each wall a vertical duplex pump of Hayward-Tyler & Company's manufacture is placed in the engine-room, taking its steam from the line of the auxiliary steam piping. The steam portion of the pump is in the engine room, but the pump barrel is placed in the interior of the dock about the level of the pontoon deck, the piston rods from the cylinders passing stuffing glands on the dock and connecting to the pump plungers. Each of these pumps is capable of providing a full stream of water for two 2½-inch fire hoses at a pressure of 120 pounds. The suction of this pump is connected to the main drain of the dock, so that it may be used as a drainage service for emptying any one particular compartment. The delivery is on the face of the dock about the level of the running deck, and is in the form of breeches pipe, finished with two screwed nozzles protected by brass caps and stopcocks. There are six pumps for the whole dock, making therefore twelve fire branches. Twenty-four 40-foot lengths of canvas fire hose with twelve fire nozzles are provided.

Each watertight compartment of the dock is provided with a means of indicating in the valve house the level of the water inside it. These indicators, supplied by Chadburn's (Ship) Telegraph Company, Ltd., are in the form of an iron inverted cup of about 4 inches diameter fastened to the frames in the bottom of each compartment. From the top of these cups or bells a pipe is led up through the interior of the dock into the valve house. These pipes are in continuous lengths, and where the pipes pass through watertight bulkheads or decks they have a watertight joint. In the valve house the ends of these pipes are soldered into a T-piece, one end of which is connected to an aneroid gage, capable of reading by pressure from a 6-inch head of water up to the highest head that can occur in the compartment in question. The other lead of the T communicates with a receiver pipe, common to all the indicators in the block, and such branch is governed by a small plug valve. The receiver pipes are connected to a small air reservoir, so that by opening the plug valve air may be forced through any of the tubes and into the compartment, the pressure necessary to do this being registered on the dial of the aneroid pressure gage. The gages are placed in the valve house, and in a prominent position as near as possible to the levers that control the valves of the compartments they indicate.

The compartment valves of the dock are all operated from one control valve house, 24 feet long by 9 feet wide, situated on the starboard wall. For this purpose the Westinghouse electro-pneumatic system is used. It is based on the principle of operating presses by air compressed to 5 or 6 atmospheres, and controlling the same from a distance by means of valves operated by an electric magnet requiring less than 1 watt to energize it. The position of the apparatus is indicated back to the valve table by electrical means. At the engine deck level each distributing valve rod is attached to the stirrup of its own press, which is of 6 inches diameter and has a stroke of 12 inches. The standard Westinghouse electro-magnetic valve is mounted on the wall of the dock. Upon the magnet being energized the exhaust passage to the press is closed and the inlet opened, and the air passes into the press, thereby lifting the distributing valve. The inlet is suitably proportioned, so that the press lifts as slowly as desired. All the time the magnet remains energized the distributing valve is lifted, but

as soon as the current is cut off by the motion of the lever on the valve table the weight of the valve and valve rod expels the air from the press, and the valve closes. Attached to the left arm of the stirrup is a circuit breaker of standard type, which indicates to the operator in the valve house the position of the press and distributing valve. A Westinghouse non-seizable cock is inserted in the air pipe of each press, so that the air can be cut off or throttled, as may be required. In the event of a failure of the electric current the control valves can be operated by hand. Should the air pressure fail, a jack or lever can be placed under the stirrup, and the valve thereby lifted by hand. The valve tables in the valve house are of timber, polished and finished in oil. On this table small levers, placed in positions corresponding to the compartments of the dock they control, actuate the necessary contacts, and electrical indicators alongside indicate the position of the distributing valves; that is, whether open or shut. The water level gages indicating the actual depth of water in the different compartments are placed to the right of the levers. The apparatus on the table is connected by wires to the battery and motors on the engine deck. There are no pipes in the valve house.

The air is supplied by a Westinghouse 8-inch by 8½-inch pump into a reservoir, from whence an air pipe is taken along each engine deck in order to supply the different presses. The capacity of the pump at 100 strokes per minute is 30 cubic feet of free air per minute. The size of the reservoir is such that the pump can raise the pressure in less than ten minutes, and that then all the valves can be lifted and closed three times in one minute without lowering the pressure too much for successful operation. A duplicate air pump is provided as a stand-by. The reservoir is placed near the pump, and it has a safety valve and blow-off cock.

The air piping is of wrought iron steam piping, and the wires are chiefly No. 18 copper of high conductivity, insulated with vulcanized india rubber of 600 megohm grade. They run in wooden troughing on the engine decks, and in 4-inch watertight piping between the port and starboard decks. Where air or cable pipings pass through watertight bulkheads the joints have been made watertight.

Electric current is provided from the main, current being reduced to required voltage. On the valve table there is a switch for cutting off the battery, so that no current is consumed for indicating the position of the pump valves except when the attendant operates the same.

For the convenience of controlling the dock, certain of the watertight divisions are grouped together, in which case such group is controlled by a single lever on the valve table. Robinson's mechanical telegraphs communicate from the valve house to the engine-room. The valve house has also been fitted with two large spirit levels—at right angles to each other—so as to indicate the levelness of the dock, in order that the valve master may have under his hand indicators giving all the information required to enable him to control the lifting and sinking of the dock from the valve house.

The electrical installation on the dock was supplied from the Sheffield works of Vickers, Sons & Maxim, Ltd. The large electrical generating unit is capable of a continuous output of about 600 amperes at 220 volts, the engine, which is of the Brotherhood vertical compound type, being connected to and supplied with steam from the main boilers. The small generating unit is capable of a continuous output of 60 amperes at 220 volts. The engine is connected to a vertical boiler fixed adjacent to the engine, and provided with a chimney, water-feed pump and injector complete independent of the main boilers. But the steam piping is arranged, and the necessary valves provided, for connecting this engine to the main boilers should it be desired to run it from this source. Each engine is provided with an approved type of governor, which maintains the speed constant within 4 percent between full load and no load. All moving parts are provided with means for continuous lubrication. The plant is capable of developing 25 percent overload for a period of two hours without undue heating. The dynamos are of the compound-wound type, arranged to give 2 percent above the stated pressure when working at full load, while the commutators are of hard-drawn or strip-forged copper, and provided with a sufficient number of segments to ensure sparkless commutation at all loads without shifting the brushes. The brushes are of the carbon type, having sufficient contact surface to prevent rise in temperature. The magnet and armature windings are of a section to ensure that the rise in temperature of any part does not exceed 70 degrees F. (21 degrees C.) above the surrounding air temperature when running continuously at full load.

There is a main switchboard erected in a position adjacent to the generating sets. On the panels of the switchboard are mounted one pair of copper bus bars, which can be divided into two parts by removable copper connecting links. One part of the bus-bars is connected by two single-pole switches and fuses to the large generator, and the other part by two single-pole switches and fuses to the small generator. To the end of the bus-bars joined to the large generator are connected through fuses the cables leading to the main connection box on the dock wall. To the other end of the bus bars are connected single-pole switches and double-pole fuses controlling the dock lighting circuits and the cross-dock cable. On this board are mounted one ammeter for each dynamo, indicating up to 25 percent above the normal output of each dynamo, and one voltmeter reading to 250 volts, which, by means of a suitable switch, can be connected to any of the dynamos or bus bars.

In an accessible position on the dock wall is a watertight cast iron box having a hinged door. Inside this box is mounted a double-pole switch having a carrying and breaking capacity 25 percent above the full load output of the generating plant, provided with four terminals, two on each pole, suitable to receive the thimbles attached to the cables for supplying power to the ship on the dock. On the opposite wall of the dock to the generating plant is erected a suitable switch pillar having a hinged door, and fitted inside with a slate or marble panel, provided with bus bars to which the cross dock cables are connected. There are also single-pole switches and double-pole fuses controlling the lamps, etc., on this side of the dock.

The outside lighting of the dock is carried out by a number of deck standards, erected at intervals along the top of the dock wall, and provided with brackets which overhang sufficiently to allow the lamps to illuminate the space between the dock walls. These brackets are capable of being turned a quarter of a revolution to prevent damage when a ship is being docked. In the base of each standard a hinged door is provided to give access to a double-pole switch and fuse mounted inside the standard. At the end of the bracket an enameled iron shade and guard is fixed, containing six lamp holders and lamps of not less than 50 candlepower. All the necessary pendent electric lamps and wall plugs are controlled by separate switches and fuses, grouped together and mounted in watertight boxes with hinged doors. At intervals along the dock walls above, but accessible from the gangway attached thereto, are mounted watertight chambers having hinged fronts and containing sockets to receive plugs for portable lamp clusters. Portable lamp clusters, consisting of four lamps contained in enameled iron shades and guard, are provided. Also single-lamp shades and guards with leads and plugs attached.

All the lamps in fixed positions and on deck standards are of the metallic filament type, working with not more than two watts per candle-power. This also applies to all portable

lamp clusters where there are more than two lamps in one cluster. Single portable lamps are of the carbon type, taking not more than 4.5 watts per candle-power.

The cables have been drawn into seamless steel tubing with screwed joints. At all places where bends occur watertight inspection chambers are provided, and where tappings are made there are watertight tee boxes. Distribution switch fuse boards are enclosed in cast iron watertight boxes, into which the conduit has been screwed. All cables and conduits are fixed inside the dock walls. The cross dock cable is of the concentric type, lead covered and armored. The valve-house, engine and boiler-rooms, and all the compartments in the top wall are wired for electric lighting, and wall plugs have also been provided in all compartments, from which inspection lamps, or small ventilating fans, or other gear can be carried to any portion of the compartments. A system of electric mains is carried inside the dock along the entire length of each of the walls, with plug boxes accessible from the outside of the dock. From these plug boxes flexible wires and lamp clusters can be led to illuminate any portion of the ship's interior.

All conductors consist of copper wire not less than 100 percent of Matthiessen standard of conductivity. No cable carries more than 1,000 amperes to the square inch. The area of cable is such that the drop in pressure from the switchboard to the farthest lamp does not exceed 2½ percent of the working pressure. The cables are insulated so as continuously to withstand a temperature of 100 degrees F. without deterioration. It was further specified that the insulation of the cables, after immersion in water for forty-eight hours, had not been less than 1,000 megohms per mile, and that the cross dock cable should be capable of periodic immersion in salt water without deterioration of the armoring or insulation.

There are two traveling cranes, one on each wall of the dock. Both were supplied by the Appleby Crane & Transporter Company, Limited. These cranes have a radius of 45 feet from the center of pivot to center of chain, and a lift of 45 feet from the top deck to the bottom of the slinging hook. They each run over the entire length of the top deck. The gear is carried on top of a four-legged traveling platform running along the rails fixed on each side of the wall of the dock. The height of the platform permits of the cranes passing over the valve houses and cowls, etc., on deck, and over the funnels, which have been made telescopic or lowering for this purpose.

Each crane is capable of lifting 5 tons on two falls of rope reeved through a snatch block, or 2½ tons on a single fall. The speed of hoist in the first case is 15 feet per minute, and in the second, 30 feet per minute. Slewing is performed at speeds not exceeding 60 feet per minute, according to the load being handled, while traveling is at the rate of 60 feet per minute. The cranes are traveled by hand by means of wire ropes secured to them and worked from the capstans. All the aforementioned movements are performed with the full load of 5 tons slung from the jib.

A substantial cast iron roller path is provided, machined on the tread, and with turned conical rollers. In addition to the stability obtained by the use of a balance weight, a pair of clip plates is fixed on each side to prevent the tipping of the cranes due to accident or rough handling, or the heeling of the dock. These consist of vertical plates, each 9 feet long, with lips projecting under the heads of the rails. Ordinary rail clips are provided at each corner to prevent the crane launching itself during docking. To suit the above clips the rails are of the flat-bottom type, with a weight of about 80 pounds per yard, and they have a wide head to afford good grip.

There are eight capstans—supplied by Messrs. Harfield. The capstan on the top deck of the wall is of cast iron. It has efficient pawling gear, and is fitted with a row of bar holes for working by hand, and has a brass cover at its head. The capstan spindle is of forged steel, and is carried down through the deck to the engine deck, and stepped into a gunmetal bushed bearing on the engine bedplate. The capstan baseplate is of cast iron, and bushed with gunmetal. Where the spindle passes through it a wrought steel collar is fitted under the boss of the capstan base, so as to prevent the spindle from lifting. The engine is of the horizontal type, with two cylinders, each 8 inches diameter by 12 inches stroke, and fitted with piston slide valves, having hard gunmetal rings. The reversing of the engines is effected by a cylindrical valve, having hard gunmetal rings, and is arranged to be worked by right-hand screw and gear, with movable handle from the top deck. Gear is supplied to enable the capstans to run at two speeds in the ratio of about 1 to 3, one for rapidly taking in slack, and the other when the full load is on the capstan. Fifteen tons are taken at 20 feet, and seven tons at 60 feet.

The control of the capstans is by removable levers of handles from the top deck of the dock.

Bollards strong enough for holding vessels of the largest size the dock is capable of accommodating are fixed on the top and at each end of the upper deck, while similar heavy bollards are provided on the projecting ends of the low wall at the stern end, and smaller bollards at the joint ends of the separate sections, for maneuvering them when they are being self-docked. Cast iron timberheads or snubbing posts are along the edge of the running decks for the purpose of checking or snubbing vessels entering the dock. Eight mechanical side shores are provided.

These shores consist of timber working inside a wrought iron tube built into the side wall of the dock. The shore carries on its underside a cast iron rack, by means of which it can be screwed in or out by a standard fixed on the top deck, and provided with two handles. The shores are marked to a scale showing the distance to which they project, and are placed opposite to each other, that is, four on each wall of the dock, so that a vessel may be centered between them. The keel and bilge blocks are of three types. First, the keel blocks proper, occurring over the central axis of the dock. Secondly, the side or docking keel-blocks, and, thirdly, the bilge blocks. The keel blocks consist of a lower portion about 2 feet high, formed of cast steel, and an upper portion consisting of a pair of oak wedges hopped at each end and strapped together, making up a height of 1 foot 9 inches. On top of these a short capping piece, also of oak, 3 inches thick, is affixed, to bring up the total height of the keel blocks to 4 feet. There are 201 of these keel blocks provided for the whole dock. The docking keel-blocks—sixty-six in number—are similar in every respect to the keel blocks, with the exception that their base is a little longer, so as to spread the load more uniformly over the floor of the pontoon. The bilge blocks—sixty-eight in number—as regards the lower portion, are again similar to the two other types, but somewhat longer, so that they can be used anywhere on the deck of the dock outside the specially strengthened zone. They carry on the top of the lower portion, which is of steel, sliding oak wedges, which can be pulled in and out by means of ropes or chains carried over pulleys and led up to the top deck. The length of these bilge blocks is 10 feet, so as to allow the bilge blocks proper to be pulled into the shape of the ship when she has taken the keel blocks. The whole of the blocks are movable, and can be shifted from one position to the other.

The working platforms at each end of the dock are strong enough to afford very appreciable support to a ship with a greater length of straight keel than 500 feet, which might have to come on the dock. For such a ship it is evident that the

side docking keel blocks would not be required, and they could, therefore, be shifted and placed as desired anywhere over the platforms. At the stern end of the dock, and on each wall, is a large timber roller fender, strongly supported on brackets, and projecting slightly beyond the line of the rubbing timbers on the painting stages. These roller fenders protect the structure of the dock from possible damage by an incoming vessel.

At the bow end of the dock a pair of flying gangways or swinging bridges affording access from one wall to the other are fixed on top of the low wall. They are of lattice construction, with their top formed of a chequered plate 3 feet wide, and protected by handrails. Means are provided for opening these gangways should the necessity arise for passing a ship out at the end of the dock. In addition to these there are two light timber bridges of a length of 20 feet, and two of a length of 30 feet, for the purpose of giving access from the top deck of the walls to the deck of the vessel on the dock.

Accommodation ladders with easy rises and treads lead from the upper deck of the dock down to the pontoon deck. There is such a ladder at each end of the wall, and, in addition, ladders lead down into all the compartments of the wall above the engine deck, while ordinary service ladders lead into each compartment of the lower wall and each watertight division of the pontoons.

Distilling apparatus of the Normandy standard type, as manufactured by the Thames Ironworks, Shipbuilding & Engineering Company, Limited, is provided on the dock, and is capable of producing 1,000 gallons of fresh water in twenty-four hours. The boiler and auxiliary boiler rooms, the engine and auxiliary engine rooms, and all portions of the dock walls where steam is used are efficiently ventilated by means of electric fans.

During the progress of the construction of the floating dock the Brazilian Government have been represented at Barrow-in-Furness by Captain J. M. de San Jaun and Dr. Olympio de Assis, assisted by Dr. Frederico Burlamaqui.

The dock left Barrow-in-Furness July 4 and arrived at Rio de Janeiro Sept. 29. On the journey to Rio the towing gear was composed as follows: On one part of the dock two heavy chain bridles were attached, and on to these were spliced 4½-inch circumference, specially flexible Bullivant steel wires of a length of 35 feet each. These wires were connected to extra superior manila ropes, 18 inches circumference and 120 fathoms length. On the other end of the ropes there were again 4½-inch steel wires fastened on to the towing bits of the tugs. The towing was done by Mesrs. Smit & Company, of Rotterdam, and this is the seventeenth floating dock which this company has delivered to oversea ports. They also have now in hand the towage to Bahia of a 1,250-ton dock, built by Messrs. William Hamilton & Company, of Port Glasgow, and another of 5,000 lifting capacity, which Messrs. Vickers, Sons & Maxim, Ltd., have on order for Aberdeen.

---

**In the annual report** of the Bureau of Construction and Repair of the United States Navy it is stated that the United States can build first-class battleships in as short a period of time as any other shipbuilding country, and actual experience seems to demonstrate that the rapidity of construction in the United States is greater than the average rate of construction in the principal foreign shipbuilding countries. This decreased time of construction has been obtained concurrently with a decrease in the unit cost of construction. In fact, the total cost per ton of displacement of battleships built by contract for the United States navy within the past few years has been less than the total cost per ton of displacement of similar vessels built in foreign countries.

## OLD TRANSATLANTIC STEAM LINERS.*

BY FRANCIS B. C. BRADLEE.

To meet this formidable opposition, the Cunards (who had started their New York service with the *Hibernia* in January, 1848) placed the paddle steamers *Asia* and *Africa* on the line. They were sister ships and magnificent steamers for their day, built in 1850 by Robert Steele, at Glasgow, of oak, double-planked, 2,226 tons gross, 266 feet long, 40 feet beam, side-lever engines by Napier, with two cylinders, each 96¼ inches in diameter, 9 feet stroke, indicating about 1,800 horsepower, but, either owing to their models or boilers, they were not quite as fast as the Collins boats, their best passage West being 10 days 10 hours, and East 10 days.

In 1852 the Cunard line built the *Arabia;* she was their last wooden paddle steamer and also the first of their fleet to be fitted with tubular boilers instead of the old return flue type. The *Arabia* was 2,403 tons gross, 285 feet long and had a set of very powerful side-lever engines (by Napier), indicating over 3,000 horsepower, but consuming no less than 120 tons of coal daily. She proved very fast in smooth water, but in a head sea she buried herself, and her engines being too powerful for her hull, she gradually worked herself to pieces and eventually was broken up. Her best time from New York to Liverpool was 9 days 17 hours in August, 1853.

Extraordinary interest was manifested in the competition on both sides of the Atlantic and heavy bets were constantly made. Notwithstanding the fact that the Collins line carried, in 1852 50 percent more passengers to New York and 30 percent more to Liverpool than the Cunards, and that Congress increased their subsidy from $385,000 (£79,000) to $858,000 (£176,000) per annum, they were not successful financially, probably owing to bad management and reckless extravagance, and a series of disasters completed their ruin. The *Arctic,* while on her passage from Liverpool to New York, was run into September 27, 1854, about 65 miles from Cape Race, during a dense fog by the French iron screw steamer *Vesta.* She was struck a few feet forward of the paddle boxes and was so severely injured that she filled in about three hours and sank stern foremost, engulfing 322 out of the 368 souls on board. Captain Luce lost control of his crew, or of the larger portion of it, who seized the boats and sought to save themselves regardless of others. Mr. E. K. Collins, one of the proprietors of the line, lost his wife, only son and two daughters, and among other passengers lost were the Duc de Grammont, an attaché of the French Embassy in Washington; F. Catherwood, a well-known artist; Edward Sanford, a distinguished New York lawyer; Professor Henry Reed, of the University of Pennsylvania, etc. It is interesting to note that at this time none of the wooden transatlantic liners were equipped with watertight bulkheads. The only ones having any were the Inman iron screw steamers, then running from Liverpool to Philadelphia, and two iron propeller steamships of the Cunard line, the *Andes* and the *Alps,* built in 1852 for their freight and emigrant service. Nor did any of the liners at that time, as far as can be traced, have steam fog horns, or show the now obligatory colored lights at night.

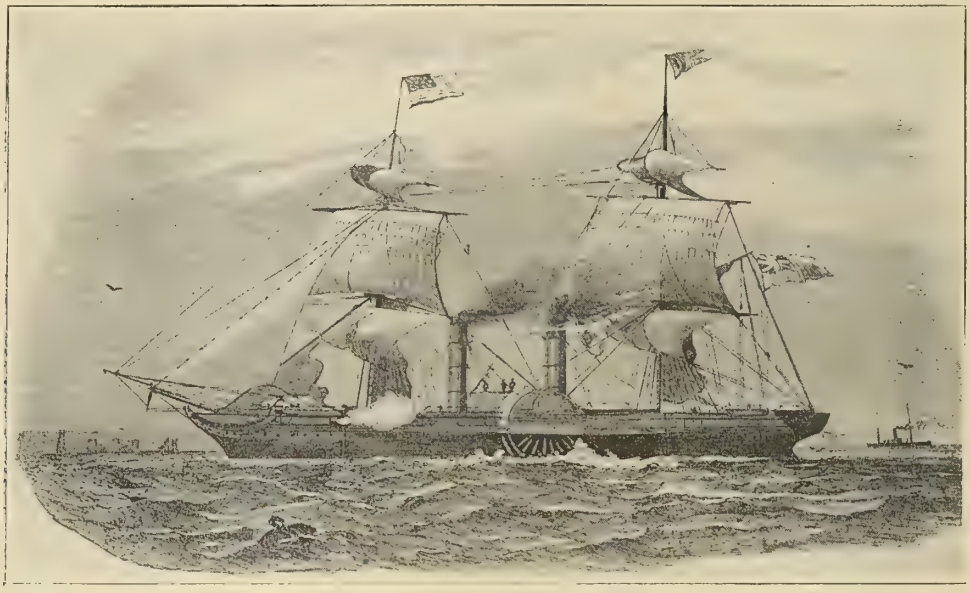
A. Fraser McDonald, who made a passage in 1848 from Liverpool to Boston in the Cunard *Niagara,* says in "Our Ocean Railways," that the only fog signal was made by a sailor standing on the forecastle and blowing a tin horn at intervals, and it was not until some time after the loss of the *Arctic* that it was stated in the Cunard line advertisement that "the British & North American Royal Mail steamers now carry a green light on the starboard side, red on the port and a white light at the masthead." Only a little more than a year elapsed after sinking of the *Arctic* when the

* Concluded from the December issue.

Collins line lost the *Pacific*. She left Liverpool for New York, running against the new Cunarder *Persia*, on January 23, 1856, with 45 passengers and a crew of 141 persons on board and was never heard of again.

From wreckage that was picked up and the experience of other steamers at about the same time, it was thought that the *Pacific* ran into an enormous ice floe and went down immediately with all hands. That these disasters were, in part, due to the intense desire of the managers of the Collins line to make fast passages there is no doubt. John H. Morrison, in his "History of American Steam Navigation," says, "This driving ahead at such a speed under conditions similar to this case (the dense fog at the time of the loss of the *Arctic*) was deemed extremely hazardous by some of the captains of the line, and one who was thought to be a very prudent commander is known to have said that he has been in the pilot house of his vessel with the engine-room bell pull in his hand and trembled for the safety of his vessel and passengers, for he was aware of the great risk he ran in dashing ahead at such a rate of speed in a fog, but it was necessary that time be made."

The last and largest of the Collins line fleet was the *Adriatic* (she was originally called the *Antarctic*), designed and built at New York by George Steers, of the yacht *America* fame. She was originally started in 1855, but owing to numerous changes in the engines was not completed until late in 1857, and in December of that year she made her first and only trip in the Collins service. The *Adriatic* was built of oak, with diagonal double-laid iron straps, was brig rigged, had two very lofty funnels and was divided into six watertight compartments. The tonnage (gross) was 4,144; dimensions: length, 351 feet; beam, 48 feet; depth, 33 feet; the ma-



CUNARD STEAMSHIP ARABIA (1853).

WOOD, SIDE-WHEEL STEAMER VANDERBILT (1855)

chinery consisted of two oscillating engines having cylinders each 100 inches in diameter, 12 feet stroke; the indicated horsepower ranged over 4,000, giving a speed of about 13½ knots on a coal consumption of 95 tons daily. The *Adriatic* was commanded by Captain James West, formerly of the *Atlantic*. After the withdrawal of the Collins line in February, 1858, the *Adriatic* was laid up for some time and then sold to the North Atlantic Steamship Company (an American line), who ran her between New York and Havre via Southampton until the early part of 1861, when she was again sold to the (English) Galway line, and while in their service ran from St. Johns, N. F., to Galway, Ireland, in 5 days 19 hours and 45 minutes (May, 1861).

When the Galway line was finally given up in 1864, the *Adriatic* was laid up in Liverpool for some time, then made into a sailing vessel, and was as late as 1899 used as a coal hulk at Sierra Leone. Such was the fate of a steamer that

THE CARROLL OF THE BALTIMORE AND LIVERPOOL STEAMSHIP COMPANY (1865).

originally cost over $1,100,000 (£226,000). The *Atlantic* and *Baltic* were used as transports during the Civil War, and during 1866-67 were employed on the North American Lloyd's line (promoted by Messrs. Ruger, of New York) between New York and Bremen via Southampton. The *Atlantic* was broken up at New York in September, 1871, and the *Baltic*, after several years' existence as a sailing vessel, was broken up at Boston in 1880.

One of the first American screw steamers to cross the Atlantic was the *Samuel S. Lewis* from Boston to Liverpool and return in October, 1851. She was a wooden boat, fitted with a pair of vertical direct-acting engines (that were not a success), having cylinders 60 inches by 40 inches stroke.

In 1855 Cornelius Vanderbilt, or "Commodore" Vanderbilt as he was better known, who had previously been identified with the Long Island Sound and coastwise lines, determined to enter the transatlantic trade. He tried to get a subsidy from the United States Government for carrying the mails, but failed, and agreed to make the experiment of transporting them for what was known as the "sea postage" only, so much per letter. He had built at New York by Jeremiah Simonson (his nephew) a large wooden side-wheel steamer named after himself, the *Vanderbilt*. She was 3,321 tons, 331 feet long, 37 feet beam, with two "walking beam" engines, built by the Allaire Works, New York, having two cylinders, each 90 inches in diameter, 12 feet stroke; the paddle wheels were of enormous diameter, 41 feet; there were four return tubular boilers, carrying a pressure of 18 pounds to the square inch; the indicated horsepower was 2,800.

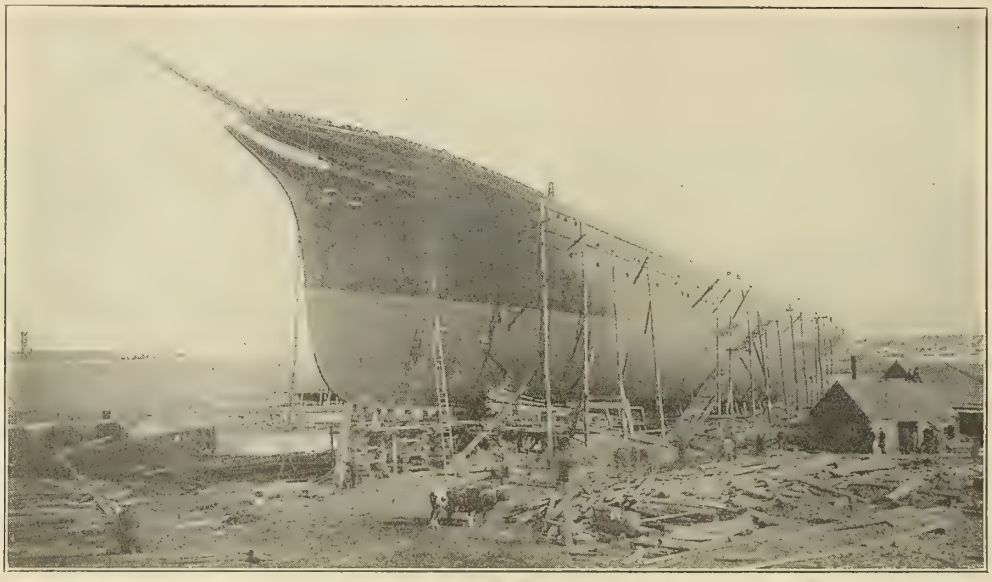
The *Vanderbilt* was a success as a fast boat, breaking the record by running from Southampton to New York, in 1860, in 9 days 7 hours, but not so much so as a comfortable one, as she rolled like a barrel and her vibration was excessive. She and several smaller boats of the same type, named the *North Star, Illinois, Ariel, Ocean Queen,* all with "walking beam" engines, some double and some single, except the *Illinois,* ran between New York and Havre, and sometimes Bremen via Southampton, during the summer months from 1855 to 1861. They did not attempt to run in the winter at all, as the "walking beams" perched up high overhead were found ill adapted to the wild weather of the "western ocean." Indeed, it is said that in stormy weather these engines would only make four or five revolutions per minute, and that the engineers had to stand by to help them over the center with the starting bar.

During the Civil War Commodore Vanderbilt presented the *Vanderbilt* to the United States Government to help catch the Confederate *Alabama,* as she was one of the few American ocean steamers capable of maintaining a speed of 13 knots. In 1863 she missed the *Alabama* at Cape Town by only a few hours, and some time before that, in 1862, just before the engagement of the *Merrimac* and *Monitor,* when the *Monitor* was an unknown quantity, the Government at Washington seriously considered loading the *Vanderbilt* and the old Collins liner *Baltic* with stone and having them run down and sink the *Merrimac* by sheer force of weight. Some years after the Civil War the *Vanderbilt* was made into a sailing vessel and called the *Three Brothers* (for some years she was the largest sailing vessel in the world); she is now a coal hulk at Gibraltar.

After the Civil War the first attempt to start a line of American transatlantic steamers was made by the Baltimore & Ohio Railroad Company, who bought three wooden screw steamers that had been built at New York in 1862 for the Government service. These were the *Worcester, Carroll* and *Somerset.* The *Worcester* was the largest of the three, being 1,500 tons gross; dimensions, 218 feet by 35 feet by 20 feet, with inverted direct-acting engines having two cylinders, each 44 inches in diameter by 48 inches stroke. The *Somerset*

opened the line by leaving Baltimore for Liverpool with the United States mail on board in October, 1865. The boats, however, were too small and slow for the trade and were withdrawn in October, 1868. The *Worcester* and *Carroll* afterwards ran for many years on the Plant line between Boston and Halifax, N. S., but have now disappeared, probably in the "bone yard."

After the Civil War trade conditions in the United States were in a very unsettled condition, and especially so was regularity until 1870, when it was given up, the reason given by the proprietors being "that a combination was formed by the English and German steamship lines to put on a steamer for New York at the same port and on the same day that the vessels for this line were advertised to sail, and to take freight and passengers to New York at reduced rates. The result of this combination was death to our line." In the early 60's the Cunarders made only bi-monthly trips to Boston. This was felt to be not enough to accommodate the



THE ERIE (1867), LARGEST WOODEN SCREW STEAMER EVER BUILT.

everything concerned with the shipping business, but, nevertheless, in 1866, William H. Webb, the noted New York shipbuilder, and Messrs. Ruger Brothers determined to try their luck in the transatlantic steamship business and accordingly formed what was known as the "North American Lloyd." Their route was from New York to Bremen via Southampton, and during the last part of their career the European

growing passenger and freight business of the port, and so the American Steamship Company was organized in 1864. Its board of directors included many merchants and business men of high standing.

After many difficulties and delays the company had built by George Jackman, Jr., at Newburyport, Mass., in 1866, two magnificent wooden (oak and hackmatac) screw steamers, the

THE OHIO, OF THE PHILADELPHIA AMERICAN STEAMSHIP COMPANY (1873).

terminus was Copenhagen and sometimes Stettin. To carry on the line the old Collins liners *Atlantic* and *Baltic* and the New York and Havre *Fulton* were bought, and various steamers, such as the *Quaker City, Western Metropolis* (which had a "walking beam" engine that had been in use on the Great Lakes in a steamer of the same name) and the *Merrimac,* an iron screw steamer built in 1862 by Harrison Loring at South Boston, were chartered.

The service was begun in 1866 and lasted with more or less

*Ontario* and *Erie.* They were 2,900 tons each, divided into five water-tight compartments, 325 feet long, 43 feet beam and 29 feet deep; the engines, designed by George W. Copeland, of New York, were built by Harrison Loring at South Boston, and consisted for each vessel of a vertical-geared engine having two cylinders, each 74 inches in diameter, 4 feet stroke, the indicated horsepower being 1,700. These two ships, at the time they were built, were considered the handsomest vessels that had ever entered Boston harbor. The

*Ontario,* Captain Hallet, sailed on her first trip to Liverpool on August 5, 1867; she made three round voyages and proved herself very fast, but on her arrival from Liverpool in January, 1868, she was laid up and the American Steamship Company went out of business. This was partly through lack of capital and partly because they failed to secure a mail contract.

The *Erie* never made a trip on the line, and after laying up for a long time both steamers were sold to the United States & Brazil Mail Steamship Company about 1870. The *Erie* was burnt at sea January 1, 1873, with a cargo of coffee on board valued at $1,500,000 (£310,000), and the *Ontario* was broken up in Boston in 1885.

After 1870 there were no lines of American transatlantic steamers until the Pennsylvania Railroad Company organized the International Navigation Company in 1872 to run steamers between Philadelphia and Liverpool. The Cramp Shipbuilding Company built and engined for the line four iron screw steamers, all alike, the *Ohio, Indiana, Illinois* and *Pennsylvania,* each ship being 3,119 tons gross, 343 feet long, 43 feet broad, 34½ feet deep, brig rigged, with vertical two-crank compound engines having cylinders 57 and 90 inches in diameter, 4 feet stroke, boiler pressure 60 pounds to the square inch. In May, 1873, the *Pennsylvania* inaugurated the service which is maintained to this day, only, as the International Company gradually expanded its fleet, the new ships were built in England and flew either the English or Belgian flag, as being cheaper to operate. After getting control of the Red Star line, running between Antwerp, New York and Philadelphia, the International Company, in 1886, bought out the Inman (English) line, running between New York and Liverpool, and in 1893 a new service was begun to Southampton under the name of American line. At the same time two of the English ships, the *City of New York* and *City of Paris,* were by special act of Congress admitted to American registry and renamed *New York* and *Paris,* the *Paris* being now called the *Philadelphia.* In 1895 the American line added to its fleet the two now well-known steel twin screw steamships *St. Louis* and *St. Paul,* which, with the *New York* and *Philadelphia,* carry on the service, and there the matter stands to-day.

---

The Bureau of Navigation of the Department of Commerce and Labor reports that 70 sail and steam vessels of 16,349 gross tons were built in the United States and officially numbered during the month of November, 1910. Three steel steamers, aggregating 6,355 gross tons, were built on the Atlantic and Gulf coasts, and 3 steel steamers, aggregating 7,760 gross tons, were built on the Great Lakes. The total tonnage of sailing vessels built during the month was 206, and all were of wood. The largest ship built on the coast during the month was the *El Occident,* 6,008 gross tons.

## SCREW FERRYBOAT DUTCHESS.

The *Dutchess* is a screw ferryboat of the following dimensions, designed and built by the T. S. Marvel Shipbuilding Company:

| | |
|---|---|
| Length over all | 160 feet 1 inch |
| Length inside of the propeller posts | 134 feet 11 inches |
| Beam over guards | 56 feet 4 inches |
| Beam, molded | 34 feet |
| Depth, molded | 14 feet 6 inches |
| Displacement | 542.7 tons |
| Net tonnage | 405 |

The principal scantlings of the hull are shown in the 'midship section, Fig. 2. The stem and shoe are of cast steel, the stem 4 inches by 7 inches and 4 inches by 6½ inches, and the shoe 5¼ inches by 9 inches. The keelson angles are 3½ inches by 3 inches by 6.6 pounds. The intercostals are of 12.5-pound plate. Between the collision bulkheads the frames are spaced 21 inches centers and at the ends 12 inches. In the engine and boiler space the reverse frames are double.

In accordance with the ferryboat law there are five watertight bulkheads. The belt frames are 11 inches wide and the

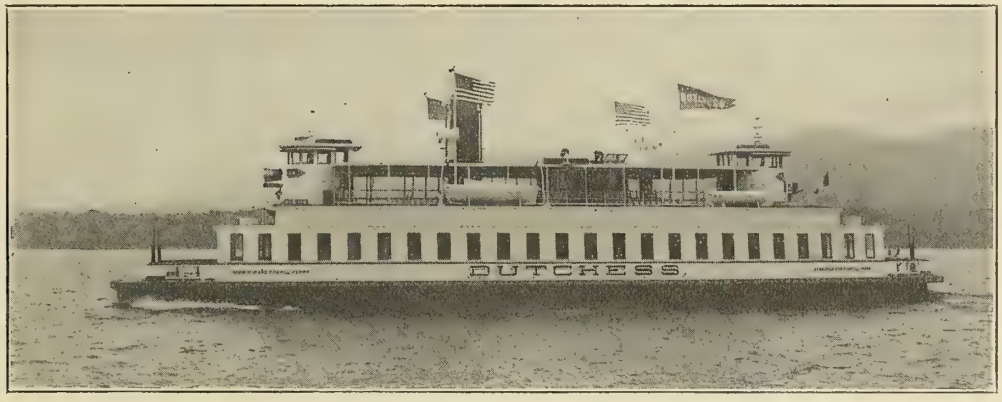



FIG. 1.—STEEL FERRY STEAMER DUTCHESS.

deck beams 5 inches by 3 inches by ⅜ inch on every frame amidships and on alternate frames at the ends. The guard beams are 5 inches by 11.6-pound zee bars.

The deck over the hull is entirely plated with 10.2-pound plate. The centerhouse and side bulkheads of the team gangway are of steel, 10.2 pounds to the square foot. The shell plating is 20 pounds for the garboards, 15 pounds for the shell amidships and 17 pounds for the sheer strake. The waterline plating is 20 pounds at the ends. All seams have joggled edges. The hull is stiffened by a longitudinal truss of channels on each side.

There is a coal bunker athwartship forward of the boilers. Cylindrical water tanks are provided with a total capacity of 6,000 gallons.

The rudders are of the balanced type with 6-inch stocks covered with 12-pound plates. There are four escape ports, 12 inches by 18 inches, and the gangway coamings are of steel.

The plank sheer is 4 inches by 18 inches, reduced to 3 inches by 15 inches at the ends. The balance of the deck planking is 3 inches by 5 inches in the teamway and 2½ inches by 2½ inches in the cabins.

The joinery work is of pine and cypress. There is a stairway on each side leading to the upper deck. The general design is colonial, modified to suit marine work. The inboard sides of the cabins are finished in canvas panels and the outboard sides with canvas panels between stationary windows. There is an awning deck over the upper deck leading from pilot-house to pilot-house.

MACHINERY.

The vessel is propelled by two comopund engines on one shaft coupled together. Each engine has cylinders 15 inches and 30 inches diameter, with a common stroke of 22 inches. Slide valves are fitted to each cylinder, operated by double-bar Stevenson link motion. Steam reversing gear is fitted and all pumps are independent. The main shaft is 7½ inches diameter. The propeller shaft is covered with a brass casing in the stern tubes between bearings. There are two thrust bearings of the horseshoe type.

The condenser outfit consists of a Blake vertical simple air pump and jet condenser, arranged to draw from a tank and total heating surface of the boilers is 1,395 square feet; the total grate surface 91 square feet, making a ratio of heating surface to grate surface of 30.6 to 1.

A vertical donkey boiler is installed in the center house and piped to the boiler circulating pumps, etc. A Reilly feed-water heater is fitted. Products of combustion from all boilers are exhausted through a double stack, 65 inches outside diameter, which extends to a height of about 53 feet 6 inches above the base line.

Electricity is supplied by a single 15-kilowatt, direct-connected General Electric generating set. Two 18-inch searchlights are installed.

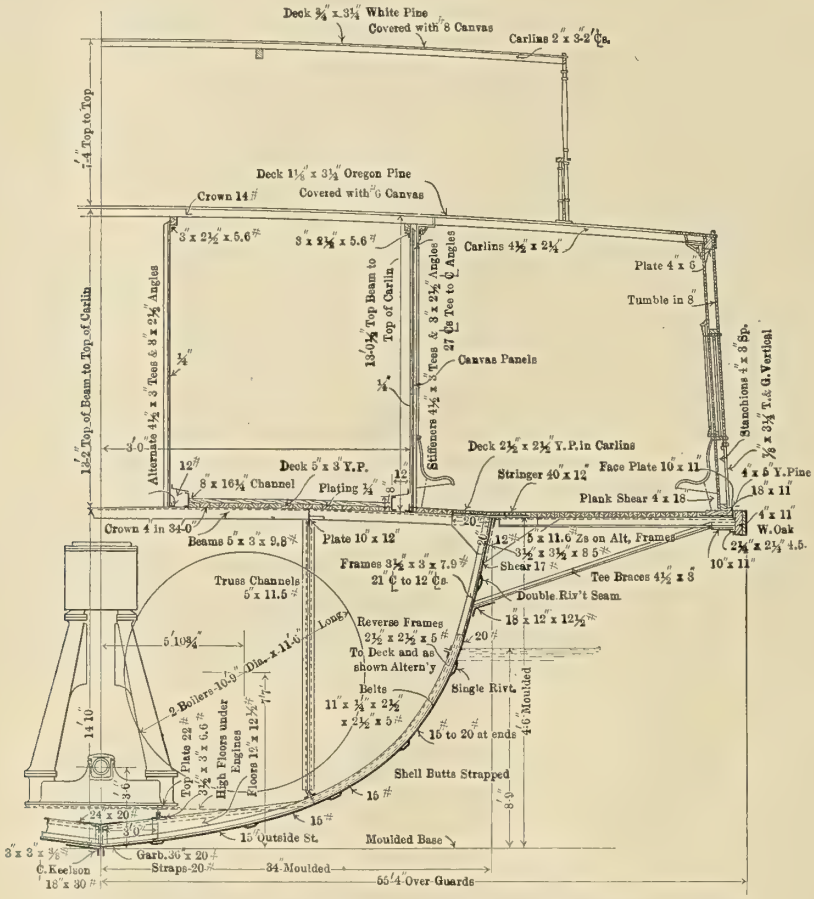

Deck ¾" x 3¼" White Pine
Covered with 8 Canvas
Carlins 2" x 3-2" Cs.
Deck 1⅛" x 3¼" Oregon Pine
Covered with 6 Canvas
Crown 14#
3" x 2½" x 5.6#
3" x 2½" x 5.6#
Carlins 4½" x 2¼"
Plate 4" x 6"
Tumble in 8"
Canvas Panels
Deck 2½" x 2½" Y.P. in Carlins
Stringer 40" x 12"
Face Plate 10" x 11"
Plank Shear 4" x 18"
Deck 5" x 3" Y.P.
8" x 16¼" Channel
Plating ¼"
Crown 4 in 34-0
Beams 5" x 3" x 9.8#
Plate 10" x 12"
Frames 3½" x 3" x 7.9#
21" ℄ to 12" ℄s.
Truss Channels 5" x 11.5#
Shear 17#
Tee Braces 4½" x 3"
Double Riv't Seam
Reverse Frames 2½" x 2½" x 5#
To Deck and as shown Altern'y
Belts 11" x ⅜" x 2½" x 2½" x 5#
Single Riv.
15 to 20# at ends
Shell Butts Strapped
Moulded Base
Garb. 36" x 20#
Straps 20#
34" Moulded
55'4" Over Guards
2 Boilers 10'-0" Dia. x 11'-6"
Top Plate 22#
High Floors under Engines
Floors 15" x 12½"
Stanchions 4" x 3" Sp.
4" x 5" Y. Pine
18" x 11"
4" x 11" W. Oak
10" x 11"

FIG. 2.—MIDSHIP SECTION OF THE DUTCHESS, SHOWING PRINCIPAL SCANTLINGS.

the sea. The size is 10 inches by 22 inches by 12 inches. There are two sea suctions of large size on each side to allow water to be drawn from the side of the boat most free of ice.

The fire pump is extra powerful, being 18½ inches by 12 inches by 12 inches. It is of the horizontal duplex type, arranged to discharge at stations in the gangway and on the upper deck. Monitor nozzles are fitted at each pilot-house.

The feed pump is 7½ inches by 5 inches by 6 inches. There are two boiler circulating pumps, 5¼ inches by 3½ inches by 5 inches.

The propellers are of cast steel, designed for winter service. They are about 7 feet 6 inches diameter.

Steam is furnished by two Scotch boilers, designed by the T. S. Marvel Shipbuilding Company, and built by P. Delaney & Company, Newburgh, N. Y. The boilers are 10 feet 9 inches diameter by 11 feet 6 inches long, designed for 135 pounds working pressure. Each has two Morison corrugated furnaces, 42 inches inside diameter, of the horse-collar type. There is a steam drum which takes steam from both boilers, and a 7-inch steam main leads from this to the engines. The

There are two sets of Welin quadrant davits complete with metallic lifeboats.

In service no vibration is noticeable, and the coal consumption is 5½ gross tons in a period of eighteen mours, or a working day.

## CONCERNING THE UNITED STATES NAVY.

In his annual report, recently published, the Secretary of the Navy makes recommendations which should result in eventual economy and tend to increase the efficiency of the naval establishment. In this connection some of the more important suggestions concern the abandonment of the naval stations at New Orleans, Pensacola, San Juan, Port Royal, New London, Sacketts Harbor and at Cavite. Secretary Meyer points out that all of these smaller stations are unnecessary and, on the whole, useless, as their location and equipment are not such as to enable a general overhaul or

accommodation of ships of the size as now built for the navy. For the protection of the Gulf and the Panama Canal, the Secretary advocates Guantanamo as possessing strategic superiority, and that this station should be properly equipped as a naval base. Owing to the increased cost in maintaining the fleet on the Pacific, it does not seem advisable, in the Secretary's opinion, to transfer any large portion of the battleship fleet there at the present time.

Although at a disadvantage, owing to its lack of railroad communications and its great distance from the labor market, the Secretary regards the Bremerton yard as necessary, and should, therefore, be developed. The Mare Island yard has the disadvantage of being inaccessible, owing to the shallowness of the channel leading to it and the impurities in the water. Too much money, however, has already been expended to abandon this yard, and it should be used for the repair of such ships as can readily be sent there. San Francisco Bay seems the logical point in the future to establish a docking and repair station for battleships.

The principal insular defense base should be made at Pearl Harbor, in Hawaii, and Alongapo, in the Philippines, should be made a repair station and Cavite disposed of.

With respect to new constructions, Secretary Meyer recommends the authorization and building of two battle-ships, one collier, one gunboat, one river gunboat, two sea-going tugs, two submarines and one submarine tender.

### REPORT OF THE ENGINEER-IN-CHIEF.

Satisfactory progress has been made on the machinery for the *Florida,* now building at the New York navy yard. As an example of the efficient organization now existing in the machinery department of this yard, is cited the successful casting of all the turbine casings for this vessel without the loss of a single casting.

One of the most important pieces of work carried out at the Norfolk yard was changing the engines of the *Louisiana* and *Virginia* from in-turning to out-turning. A highly gratifying feature of this work rests in the fact that it was done for about 55 percent of what the contractors, who built these two ships, wanted for doing this work after the engines had been completed as in-turning.

Boilers of both Babcock & Wilcox and Mosher type have been tested by the builders of said boilers in accordance with requirements stipulated in the bureau's specifications, with special regard to acceptance for battleship installations.

In order to determine the relative backing power of ships with turbines and reciprocating engines exhaustive trials were undertaken with the three scout cruisers, *Birmingham, Chester* and *Salem.*

The experience gained with the burning of oil fuel as auxiliary to coal in the battleships *Delaware* and *North Dakota* shows that satisfactory burning of the oil, which, when used as indicated, is sprayed on top of the coal, and, therefore, with lessened furnace volume and space for combustion, has been difficult of accomplishment. As installed in these two vessels, it is intended to be used only to assist in maintaining power on long full-power runs.

A high-speed marine turbine, with reduction gear, is being installed in the collier *Neptune.* This is a twin-screw vessel of 19,360 tons displacement, with a speed of 14 knots. Steam is supplied to each of the two Westinghouse-Parsons turbines at 200 pounds gage. The power expected is 4,000 horsepower on each shaft when the turbines revolve at 1,500 revolutions per minute, while the propellers run at 136 revolutions per minute. The reduction gear is of the Melville-Macalpine type.

Recommendation is renewed for an appropriation of $250,000 (£51,400) for the pruchase of internal combustion engines, to be installed in a naval collier, should it be thought advisable to experiment along these lines.

## BIDS AND CONTRACTS FOR UNITED STATES NAVAL VESSELS.

### TORPEDO-BOAT DESTROYERS.

On Nov. 8 last, bids were opened at the Navy Department, Washington, for six torpedo-boat destroyers, the contracts for which were awarded on Nov. 22. The awards were made as follows:

The Bath Iron Works, Bath, Me., two destroyers at $645,000 (£132,500) each, to be completed within 24 months and a guaranteed speed of 30 knots.

The Newport News Shipbuilding & Dry Dock Company, Newport News, Va., one destroyer; to be completed within 24 months and a guaranteed speed of 29½ knots, at a price of $630,000 (£129,400).

The New York Shipbuilding Company, Camden, N. J., one destroyer at $640,000 (£131,500), to be completed within 24 months and a guaranteed speed of 29½ knots.

The Wm. Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa., one destroyer at $653,000 (£134,000), to be completed within 24 months and a guaranteed speed of 29½ knots.

The Fore River Shipbuilding Company, Quincy, Mass., one destroyer at $648,700 (£133,200), to be completed within 24 months and a guaranteed speed of 29½ knots.

The machinery of the first five are to be turbines of Parsons type, and that of the last-named to have Curtis turbines with twin screws. The boats to be built by the Bath Iron Works and the Fore River Ship Building Company to have their trials on the regular Government trial course off Rockland, Me.; the others on the Lewes-Delaware course, for the privilege of which the builders made a reduction of $5,000 (£1,030) on each boat.

All of the foregoing destroyers have practically the same dimensions as those contracted for in September, 1908, and May, 1909, which are 742-tons displacement and have 12,500 horsepower.

### BATTLESHIPS NEW YORK AND TEXAS.

Owing to restrictions contained in an amendment to the bill authorizing the construction of the two latest battleships, Nos. 34 and 35, which provide for an eight-hour workday, only one bid was received by the Department Dec. 1, the date set for opening bids. The bid referred to was by the Newport News Ship Building and Dry Dock Company, Newport News, Va., who offered to build one battleship (No. 35) according to the following schedule:

Class 1. Department's plans for hull and machinery, with turbines of Parsons type, for $5,790,000 (£1,191,000), or with turbines of Curtis type for $5,775,000 (£1,181,000). Class 2, Department's plans for hull and builders' plans for machinery, with reciprocating engines, for $5,830,000 (£1,199,000).

The ship to be completed in 36 months and have a guaranteed speed of 21 knots. The bill also authorizes the Secretary of the Navy to build one of these two ships at a navy yard, but, owing to the increased cost, this will not be decided upon before Congress authorizes the limit of the increase in cost. Meanwhile, the Newport News Company has informed the Department of its willingness to construct both ships at a price for each given in their bid for one. Should Congress decide to build the *New York* by private contract new bids for this ship would probably be invited.

The General Electric Company in their bid for machinery offered to build machinery of a turbo-electric type for $352,000 (£72,400).

### COLLIERS.

Two bids were received for the construction of colliers Nos. 9 and 10. One of these, from the Union Iron Works, San Francisco, Cal., offers to build one vessel for $1,595,000 (£328,000) in accordance with the Department's specifications.

The other bid, from the Moran Company, Seattle, Wash., offers to build one vessel, on specifications prepared by the company for the machinery and the Department's plans for hull, for $987,000 (£203,000).

The first bid exceeds the limit of the appropriation by $595,000 (£122,300), and the second bid was unaccompanied by the required bond, and irregular also in other respects.

GUNS AND ARMOR.

The Midvale and Bethlehem Steel Companies submitted identical bids for the armor plates to be used in the construction of battleships, and were as follows:

Class A, 11,340 tons at $480 (£99) per ton.

Turret armor, 1,416 tons at $480 (£99) per ton.

Class C, at $470 (£97) per ton.

Class D, at $655 (£135) per ton.

Class E, at $512 (£105) (Midvale), and $508 (£104) (Bethlehem).

Bids for ten 14-inch guns complete, including some spares, but without gun carriages, the Midvale Steel Company's bid was $747,700 (£153,700), and that of the Bethlehem Steel Company $779,000 (£160,000). The time of delivery of the first gun of the former company was 13½ months, and that of the latter 14 months, thereafter one gun every 60 days.

## NAVAL ENGINEERING PROGRESS.

BY ENGINEER-IN-CHIEF H. I. CONE, U. S. N.

SCOUT TRIALS.

Extensive trials have been carried on with the *Birmingham, Chester* and *Salem*—scout cruisers, similar in design except as regards their machinery installation. The *Birmingham* has reciprocating engines on two shafts; the *Chester,* Parsons turbines on four shafts; and the *Salem,* Curtis turbines on two shafts. The boilers on the *Birmingham* and *Salem* are identical in design, while those on the *Chester* are of similar type.

At a speed of about ten knots the total water per hour for the main engines only is 21,988 pounds for the *Birmingham,* 25,492 for the *Chester* and 30,182 for the *Salem.*

On full power, with respective speeds of 24.15, 24.67 and 25.12 knots, this water consumption is 253,372 pounds for the *Birmingham,* 253,662 pounds for the *Chester* and 292,751 pounds for the *Salem,* or 17.42 pounds per indicated horsepower, 13.7 pounds per shaft horsepower and 16.2 pounds per shaft horsepower, respectively.

The speeds on contract trials were: *Birmingham,* 24,325 knots; *Chester,* 26.52 knots; *Salem,* 25.947 knots.

An interesting point developed in the trials is the economy obtained in the Parsons system by the use of cruising turbines at low power. These cruising turbines have been omitted in recent British designs. At 10 knots, with the cruising turbines, a water rate of 28.1 pounds per shaft horsepower was obtained; while without the cruising turbines this increased to 44.9 pounds per shaft horsepower.

In comparing the results of these trials it should be remembered that the Curtis turbines of the *Salem* represent a much earlier period of development than do the Parsons turbines of the *Chester.*

STEAM TRIALS OF THE DELAWARE AND NORTH DAKOTA.

The trials of the *Delaware* and *North Dakota* present an interesting study in similar ships of the comparative efficiencies of reciprocating engines and Curtis turbines in battleships.

The *Delaware,* which is our latest and perhaps last reciprocating-engined battleship, showed such an excellent performance on her contract trial that there is doubt in the minds of some of us as to the superiority of the turbine for a battleship of that type and speed. The steam consumption per indicated horsepower of the main engines was 15.48 pounds at 12 knots, 12.7 pounds at 19 knots and 12.9 pounds at 21 knots.

As compared with the *North Dakota* the main engines of the *Delaware* showed a smaller steam consumption at all speeds, and at 12 knots this superior economy amounted to about one-third the total consumption. Translated into cruising radius, this superiority, if maintained on service, is significantly important.

The principal improvements in the *Delaware's* machinery over that of her predecessor's consist in:

(*a*) Improved cylinder ratios and reduced clearance in main engines.

(*b*) Forced lubrication of main bearings, crank pins, eccentrics and cross-head pins.

(*c*) The use of superheated steam.

Forced lubrication similar to that of the *Delaware* is being applied to the older vessels. During the present year it will be fitted to the *Vermont, New Hampshire, Georgia, North Carolina, California* and *Colorado,* and, if it proves successful, as rapidly as possible to the other armored vessels of the fleet.

Some difficulties have developed in connection with the use of superheated steam, due to erosion of valves in the steam lines of the *Delaware,* and there is still some doubt as to whether the economy gained is not counterbalanced by the increased difficulty of maintenance of plant. We are experimenting with metals suited to high temperatures, and hope to find a valve material to overcome these troubles.

THE BACKING POWER OF TURBINES AS COMPARED WITH RECIPROCATING ENGINES.

With reciprocating engines a backing power equal to the ahead power is afforded without any increase in weight except that of the backing eccentrics, rods and links. With turbines, however, the ability to reverse requires additional turbines, with a considerable increase in weight.

It is necessary, therefore, to restrict the backing power of turbines to that actually required by tactical considerations. The intention has been to provide a backing power estimated at 50 percent of the ahead power. In practice, however, the backing power of turbine vessels has been found not to exceed 40 percent of the ahead power.

Trials have recently been held with the three scout cruisers to determine the sufficiency of the backing power provided by Parsons and by Curtis turbines, as compared with that obtained by reciprocating engines. The basis of comparison has been taken as the distance ahead reached by the vessel during the interval required to bring her dead in the water from a given speed ahead.

These trials were conducted with great care and thoroughness, the condition of displacement, sea speed, and number of boilers in use, were practically identical for all, and the results may be taken as an authoritative indication of the relative backing powers of the three types of machinery as now installed.

The speeds selected for the trials were 10, 16, 22 and 24 knots. Three runs were made by each vessel at each of the two lower speeds, two runs at 22 knots, and one run at the high speeds. At each speed only the boilers required for a sustained run at this speed were used.

There was no bottling up of steam preparatory to backing, and no speeding up of blowers during the backing interval. It was required that the boiler pressure be not reduced to such extent as to cause priming.

It was found that at all speeds the reciprocating engine provides better backing power than the Curtis turbines, and that the latter is superior to the Parsons turbine.

* Abstract of a lecture delivered at the Naval War College at Newport, R. I., August, 1910.

The commanding officer of the *Chester* (with Parsons turbines) states: "However, under all the usual experiences of service, I have felt, during the past four months' experience, no uneasiness as to the adequacy of the backing power, provided I always had six boilers in operation." The *Chester* has twelve boilers, and on the trials six were used at 10 knots with natural draft.

The adequacy of the *Chester's* backing power is, I believe, debatable, and I submit it to you gentlemen, it being a tactical rather than an engineering question.

Similar trials are to be carried out with the *North Dakota* and *Delaware*.

The British battleship *Dreadnought*, displacing 17,900 tons, and with 23,000 shaft horsepower in Parsons turbines, at a speed of 20 knots, was stopped in three minutes in 5.9 ship lengths, and at 12 knots in 4.2 ship lengths, the time for the latter speed not being given.

The strategical features governing the design of naval machinery are quite different in the case of other nations with whose vessels ours are ordinarily compared. Certain European nations, for instance, are building fleets for service in the North Sea. Their probable enemies are close at hand, the probable sphere of their naval activities is limited, and, as a result, their fleets must be prepared to make short changes of base at high speed. The result is apparent in recent British designs, in which the predominant features are high speed and simplicity of machinery, at the expense of cruising radius. For their purpose the increased economy gained by the use of cruising turbines is not justified by the increased weight, space and complexity involved.

We, however, must build our ships for service beyond the seas. Economy of fuel at cruising speed is to us of paramount importance, and our problem becomes the difficult one of combining a maximum of cruising radius with an ability to make the speed required by tactical considerations.

This extends even to our destroyers. Their cruising radius should approximate that of the battleship fleet, and this at a sustained speed of 15 knots. We are now considering in the designs of the new destroyers methods of reducing their steam consumption at 15 knots, in an endeavor to build up their cruising radius at this speed. Two methods present themselves. In the one the cruising turbines hitherto shown in our three-shaft destroyers are replaced by small high-speed turbines connected by mechanical reduction gear to the low-pressure shafts. A clutch coupling is interposed to permit throwing out the cruising element at the highest speeds and when backing. The small turbine works the steam from the boiler pressure down to about atmospheric pressure, and exhausts through the main turbines, the power at 15 knots being about equally divided between the three shafts.

The other proposition is to install a small reciprocating engine in place of the high-speed turbine and reduction gear. On account of the low power required for 15 knots (about 450 horsepower on each shaft), and because of the comparatively high efficiency of the reciprocating engine when working in the range of pressure presented, the design of an engine which will be satisfactory on service is by no means difficult. A moderate piston speed and forced lubrication can be provided which should insure ease of upkeep.

Either of these proposed cruising elements can be installed within the weight and space of the cruising turbines hitherto used, and each method promises an improvement in economy of about 20 percent. The resulting increase in cruising radius may justify the departure from simplicity of plant entailed by the employment of one of these methods, particularly since total disability of the cruising elements would still leave a full-powered plant.

### PROSPECTIVE DEVELOPMENTS IN METHODS OF PROPULSION.

Although there have been marked improvements in the design of recent turbine machinery, an all-turbine installation in a battleship is still unsatisfactory as regards economy of coal at cruising speeds, due to the inefficiency of the turbine at low peripheral speeds. There is, therefore, a well-defined need for a method of propulsion which, at cruising speeds, will allow a high-speed turbine to drive a slowly-revolving propeller shaft, thus conserving both turbine and propeller efficiencies. It is probable that three methods of propulsion radically different from existing types and all aiming to accomplish this end will be tried within the next two years.

### HIGH-SPEED MARINE STEAM TURBINE WITH REDUCTION GEAR.

This form of drive is to be installed in the collier *Neptune*, building at the works of the Maryland Steel Company, Sparrows Point, Md. She is to be a twin-screw vessel, similar to the *Cyclops*, displacing 19,360 tons, with a speed of 14 knots. Steam at pressure of 200 pounds will be supplied by three double-end Scotch boilers to a Westinghouse-Parsons turbine for each shaft, each turbine developing about 4,000 shaft horsepower on 1,500 revolutions at full power. Between each turbine and its propeller shaft is to be interposed a Melville-Macalpine gear, reducing the propeller speeds to 135 revolutions per minute at 14 knots. Low speeds are obtained by slowing down the turbine, and astern turbines are provided for backing.

It is expected that, incidental to the trial of this method of propulsion, the installation in the collier will afford an opportunity to benefit by the broad experience of the Westinghouse Company in the development of details of the work. For instance, it is proposed to adapt the company's electro-pneumatic railway-switch-operating mechanism to permit the operation of the machinery from the bridge. Again, the installation will permit a trial of the Leblanc air pump, as used by the company in its commercial work, and of radical changes in design and construction of the Parsons turbine.

This installation is being made on very liberal terms to the Government, the cost being that of the reciprocating engines originally contemplated, and the Government being duly guaranteed against possible failure.

The principal points to be developed with this installation are the extent of wear on the gears, quietness of operation, and the adaptability of the gears for reversing. In shop tests the gear has transmitted 4,500 shaft horsepower for 40 hours, with an efficiency in excess of 98 percent, and with no apparent tendency to wear.

### EMMET'S METHOD OF ELECTRIC PROPULSION.

Mr. W. L. R. Emmet, an engineer of the General Electric Company, has submitted a form of electric propulsion in which General Electric high-speed turbo-generators drive motors on the propeller shafts at speeds considered proper for propeller efficiency. He estimates an efficiency of transmission of 94 percent. His installation in a battleship contemplates two turbo-generators driving four motors on two main shafts. By this multiplicity of units, combined with pole-changing devices on two of the motors, an economy close to the maximum is promised at all speeds above ten knots.

In the case of a collier, whose cruising speed would probably be near her maximum, the installation proposed consists of two generators and two motors, one on each propeller shaft. The motors would not be arranged for pole-changing, but would be equipped with resistance for reversing. At speeds below 11 knots one generator would be used on both motors. At a speed of 14 knots a water rate of 12.6

pounds per shaft horsepower per hour is promised, and at 10 knots the water rate is stated to be less than 15 pounds.

It is hoped that this method of propulsion may be installed in a collier authorized by the last Congress, similar to the *Neptune,* under conditions similar to those governing the Westinghouse installation in the latter vessel.

Although many of the features of the electric drive proposed by Mr. Emmet have been developed as the result of actual installations in shore plants, there are so many novel features involved that the system will require careful scrutiny before its use in an important vessel is considered. It is difficult to predict what disadvantages, if any, will be found, but the following points will be the subject of special investigation in the trial installation:

(*a*) Weight as compared with all-turbine drive.

(*b*) Ventilation of the generators and motors, there being considerable heat generated in the armatures.

(*c*) Cooling of resistances. Under certain conditions there are large quantities of heat to be suddenly dissipated from the resistances.

(*d*) The possible failure of the machines, or parts of the machines, due to access of water.

(*e*) Complexity of accessories—switches, pole-changing devices, resistances, etc.

(*f*) The degree of delicacy of speed control.

(*g*) The effect on chronometers, compasses, and personnel of grounds, the tension being in excess of 2,000 volts.

### THE MAVOR AND COULSON SYSTEM OF ELECTRIC DRIVE.

This system is based on an ingenious spinner motor, which gives three speeds in either direction at maximum motor efficiency, control being had from two double-throw switches.

The motor consists of an ordinary squirrel-cage rotor on the main shaft. Concentric with the rotor and around it, adapted to revolve freely on extensions of the main-shaft bearings, is a spinner, provided with a brake. On its inside surface the spinner is wound to drive the rotor, while on its outside periphery the spinner has a squirrel-cage winding that enables it, in turn, to be driven as a motor by a surrounding stator built into the ship. Thus the machine consists of two motors concentrically arranged around a common axis, either of which may be made to revolve in either direction, or the spinner may be held by the brake while the rotor is revolving. The speed of the spinner, in this manner, may be added to or subtracted from that of the rotor, giving three speeds in either direction without the use of resistances in the rotor circuit, without varying the periodicity of the main circuit and without pole changing. The relative speeds of the rotor and spinner are determined by the number of the poles in the spinner and stator.

In the case of a battleship similar to the *Florida,* this method would contemplate a three-shaft arrangement, developing 30,000 electrical horsepower at 150 revolutions per minute. The estimated loss in transmission in dynamos and motors is 10 percent, which, it is claimed, would be more than compensated for by the gain in turbine and propeller efficiencies.

The turbo-generators would have a speed of 1,200 revolution per minute. The rotor revolves at 90 revolutions per minute, the stator at 60. The three speeds at which maximum efficiency would be obtained are, therefore, 30, 90, and 150 revolutions per minute, corresponding, respectively, to steerage way, to 10 knots, and to 20.5 knots.

The equipment would weigh considerably more than an all-turbine arrangement. The overall diameter of motors would be 15 feet.

It is reported that an installation of bituminous producer-gas engines, driving generators for this method of propulsion, is to be installed on a cargo vessel on the Great Lakes during the present year. No reliable data concerning this installation have been received. Its development will be followed with great interest.

### NUMBER OF PROPELLER SHAFTS.

Having definitely abandoned the single screw for all important vessels, it is almost axiomatic that an arrangement of propelling machinery on two shafts is the best that remains, for reasons of simplicity and of propeller efficiencies. But we are sometimes forced into a three or four shaft arrangement for reaction-turbine ships by the excessive length of engine room which otherwise would be required. This is not without advantages, however, in the ease of overhaul afforded by the smaller turbines and in the minimizing of the effect, on the total propulsive power of the vessel, of damage to one of the units.

As between three shafts and four shafts the latter are preferred for large vessels, on account of the probability of better propeller efficiencies. Our lack of experience renders the design of the center propeller in a three-shaft arrangement rather difficult. The proximity of this propeller to the hull and the likelihood of its being robbed of its water by the wing propellers introduces an element of uncertainty as to its efficiency. It is probable that when properly designed and located three screws will give almost the same efficiency as two or four, yet there are startling instances of trials of triple-screw vessels in which the best speeds were obtained with the center screw idle. We have rejected the three-shaft arrangement for the new battleships, because with reaction turbines the four-shaft arrangement requires a shorter engine room. With impulse turbines the two-shaft design gives more room and greater simplicity on less weight; but, in case we go to higher powers in our future battleships, three screws will probably be necessary in order to avoid excessively large units.

In the case of destroyers we use three shafts for Parsons turbines and two shafts for the Curtis and Zoelly turbines.

### INTERNAL-COMBUSTION ENGINES.

Tests have recently been completed at the Norfolk Navy Yard of internal-combustion engines for launches. Nineteen representative makers submitted engines for the tests. Each engine was tested for four or five days in the shop, and an equal length of time in a 40-foot launch.

As a result of these tests, eight 4-cycle gasoline (petrol) engines and one 2-cycle kerosene (paraffin) engine were found suitable for naval use.

A gasoline (petrol) engine, to be sufficiently reliable for service use, must be of heavy construction and securely mounted in a heavily-built boat. It has been conclusively demonstrated that a lightly-built high-speed engine, however carefully built and operated, will not serve. A 4-cycle engine should weigh not less than 45 pounds per horsepower, and the 2-cycle engine (for small powers) not less than 35 pounds per horsepower. The revolutions should not be much greater than 500 per minute.

Designs are being prepared in the Bureau of Steam Engineering for standard gasoline (petrol) engines for service use. It is probable that eventually the heavy-oil engine will displace the gasoline (petrol) engine on account of the danger incident to keeping gasoline (petrol) on board ship. The department is bending every effort towards the development of an oil engine suitable for small boats.

The use of internal-combustion engines for propulsion of large vessels has long been an attractive subject to naval engineers. Such engines have shown marked economy in large units on shore with constant load when run by producer gas. We are often asked why we do not use such engines in naval vessels. The variations in load, the provision that must be

made for reversing, and the necessity for a control of speed in a marine installation, sufficiently delicate for maneuvering, present difficulties that have not thus far been successfully met. There are difficulties, too, in connection with the design of a producer suitable for bituminous coal. The size of gas-engine cylinders suitable for marine work is at present limited to about 100 horsepower on account of temperature difficulties in larger cylinders. Thus, in the present state of the art, an installation for one of the new battleships would require 320 cylinders, and, needless to say, limitations of space alone would prohibit such an installation. With a gas engine, too, the cylinders are absolutely independent, one of the other; there is no mutual understanding, as with the cylinders of a steam engine, in which each cylinder is very much concerned with the performance of its neighbors. For this reason the problem of simultaneously reversing all the cylinders of a gas engine is a difficult one.

The British gunboat *Rattler* was in commission for about eight months, with an anthracite producer supplying gas to a 5-cylinder, 500 horsepower single-acting engine, making 120 revolutions per minute, exhausting into the smokestack. Speed could not be reduced below 65 turns. A hydraulic clutch was used for reversing; this wore badly and was unsatisfactory. The weight of the installation was greater than that of a steam plant of equal power.

At present, therefore, internal-combustion engines are unsuited for marine installations of greater than 1,000 horsepower, and in small installations are justified only in special cases. There is, however, prospect of a considerable improvement in the design of bituminous producers, and a well-directed effort to overcome the difficulties which I have enumerated, so that the subject is still very much alive.

Our experience with internal-combustion engines in launches is that their maintenance is very expensive, amounting to 35 percent per annum of the original cost.

In the British and German navies, heavy-oil engines are used to drive a portion of the dynamo plant on some of the recent vessels. Such an arrangement permits the lighting and ventilation of the ship when, for purposes of overhaul, all boilers are cold.

With us, however, this contingency is so remote that the use of internal-combustion dynamo engines has not been justified. Our principal navy yards are all capable of furnishing current to ships whose dynamo plants are disabled.

### OIL-BURNING BATTLESHIPS.

Our experience with liquid fuel, while limited, has been sufficient to convice me that, considered from an engineering point of view, the expediency of its use in battleships to the exclusion of coal is clearly indicated.

The principal argument advanced against the use of liquid fuel, in large vessels, is the alleged difficulty and uncertainty of obtaining it in the seaports of the world. This is a strategical question, and belongs to you gentlemen rather than to me, but I will discuss it very briefly. New oil fields are being developed in many localities where until recently they were unknown. The Argentine Government has directed the installation of oil burning as an auxiliary in their battleships that are being built in this country, and in connection with this appears the statement that large oil fields have recently been discovered in Patagonia. California produces an excellent grade of fuel oil, but we are sending Pocahontas coal around the Horn for use in our vessels on the West Coast. I have seen the statement that the new oil fields in Oklahoma produced last year an amount of oil equal to twice the coal burned by the United States navy during the same time.

The United States produces more than half the world's oil supply, and it is being shipped abroad for use as fuel in the vessels of foreign navies. It would appear that fear of difficulty in obtaining oil should not seriously interfere with the adoption of this ideal fuel for use in United States naval vessels.

In time of war we must depend on the fuel stored at our naval bases or carried in our cargo vessels; and it is easier to store and carry oil than coal. With the Panama Canal completed, oiling stations at our possessions in the Pacific, together with some oil-carrying vessels, would afford a certainty of fuel supply at least equal to that now provided for coal.

It should be remembered that all our future destroyers will probably be oil burners, and that their work is with the battle fleet. Thus we are already committed to the establishment of means of supplying oil for the destroyers at all bases at which it would be required by battleships.

That oil-burning battleships have not been advocated more seriously abroad is due entirely to the fact that, with the exception of Russia, no European nation has a supply of oil that can be depended on in time of war. It is logical, therefore, that our nation, producing, as it does, more than one-half the world's supply of fuel oil, should be the first to accept the great military advantages of oil-burning battleships. These advantages have been argued so often that I will not dwell upon them now. Briefly, with liquid fuel, we can:

(*a*) Reduce the weights and space required for boilers.

(*b*) Reduce the fireroom personnel.

(*c*) Eliminate ashes and cinders, and practically eliminate smoke.

(*d*) Increase the cruising radius.

The principal advantage, from a military point of view, of oil burning in a turbine-driven vessel, lies in the ability of such a vessel to be driven at full power with but slightly greater effort on the part of the personnel than at low speed, and in the fact that full speed can be maintained for periods limited only by the supply of fuel.

I wish to place myself emphatically on record as advocating oil-burning battleships for our service.

### IMPROVEMENTS IN ECONOMY ON BATTLESHIP FLEET.

In comparing the present coal consumption of the battleship fleet, which means its cruising radius, we will use as a standard that shown on the cruise of the battle fleet from San Francisco to Hampton Roads, during which, as you will remember, a considerable improvement was shown over the first leg of the world cruise.

The average coal consumption per knot of the battle fleet at present, referred to a standard speed, is 6 percent better than that of the best ship on the world cruise.

The average coal consumption per knot of the battle fleet at present, at 12 knots, is practically the same as that at 10 knots on the world cruise.

Since the world cruise there has been an improvement in coal consumption per knot in the battle fleet of 20 percent.

There is a similar improvement in the small vessels of the service.

The armored cruisers have apparently not improved, but are burning a little over 1 percent more coal per knot than last year.

In consumption of lubricating oil per knot there has been an improvement of 8 percent from December, 1909, to April, 1910, over that of the preceding year for all vessels of the navy. The average cost per knot of lubricating oil for all vessels is now 3.9 cents. This is not as good as the best merchant practice, but is constantly being improved. Our best ships cost less than one cent per knot.

As illustrating the ability of ships to maintain themselves, the cost of repairs due to casualties was four-tenths of a

cent per horsepower during the last year. The cost of new machinery and boilers for naval vessels, included under the head of "navy yard repairs and changes," was 53 cents per horsepower during this period.

Including the power of the auxiliary machinery the average cost of developing one horsepower in the navy is now about 2.04 pounds of coal per hour. This includes all expenditures of coal for whatever purpose, and also includes all power developed for whatever purpose. The figure is the average result, as shown by the steam logs of vessels in service. The ratio between the average power developed and the maximum power of naval vessels is extremely low as compared with any economical commercial practice. Considering this low-power factor the present result is not bad. The coal efficiency compares very favorably with that obtained under steaming conditions elsewhere. According to reports received, in one very large navy the cost in coal of developing a horsepower-hour is 25 percent greater than in the United States navy. These improvements in coal economy have been principally due to the following causes:

(*a*) *The converting of evaporating plants from single to double effect.* The power to distil fresh water sufficient for all purposes is a most essential feature in self-maintenance, and especially so if engaged in a compaign. The economy in making water simply means that the radius of action is increased accordingly. The gain in economy from the use of the double effect is theoretically 48 percent. Actual gains of from 35 to 40 percent are obtained. There is no appreciable reduction in the capacity of the plant.

(*b*) *More careful and systematic firing, induced by analysis of smoke-pipe gases.* Most of the larger ships have been equipped with apparatus for sampling smoke-pipe gases, and determining the proportion of $CO_2$ therein. It is found that the percentage of $CO_2$ gives an accurate measure of the efficiency of combustion when coal is used as fuel. The principal furnace loss is the heat in the excess air which passes up the funnel. With a $CO_2$ percentage of 14, a condition of maximum efficiency is obtained in which there is no excess of air. Should this drop to 5 percent, as was the condition in many of our ships when this apparatus was first installed, there is a loss in efficiency of 24 percent, due to excess air. In some of the ships a record of the $CO_2$ percentage of each fireman is kept, and the ability of the fireman is rated thereby. On one ship, where this system is followed, it was found that the number of buckets of coal required per watch varied progressively from 30.5, with a $CO_2$ percentage of 11.9 to 34.4, with a percentage of 9.0, the amount of steam generated remaining the same. One of the first things learned by gas analysis was that our boiler casings leaked air. These have been made tight, with a corresponding saving in coal, reported in some cases to amount to as much as eight percent.

(*c*) *The tightening of the pressure parts of boilers, particularly the bottom-blow valves.* A new type of valve has been fitted on the larger ships during the past year, which removes a serious source of loss that has hitherto existed, due to the inability to keep the valves of the old type tight.

(*d*) *More efficient propellers* have been fitted on the *Kansas* and *North Carolina,* and are being made for the *Mississippi* and *Vermont.* As soon as accurate data on the efficiency of existing propellers under service conditions can be obtained, it is hoped to improve the efficiency of the fleet as a whole by replacing those propellers which are least efficient at cruising speeds.

(*e*) *Greater attention to steam traps.* It is found that leaky traps have in the past caused considerable losses.

(*f*) *A more careful attention to auxiliary machinery, particularly to the condition of the valves and steam cylinders.* In a battleship at cruising speed, one-third of all the steam generated by the boilers is used in the auxiliaries.

As the service in general fully realizes, smokeless combustion is greatly to be desired, and, while we have made some progress along this line, notably in the new coal-burning destroyers, still the problem has not been solved as yet. There are a number of smoke-consuming devices on the market, but we have been unable to find one that is even fairly efficient in a shore plant, and practically all are prohibitive in service installations because of confined space and high rate of combustion, and especially from the fact that nearly every one of them requires the expenditure of considerable steam for its operation.

### FULL-POWER TRIALS OF BATTLESHIPS.

Full-power trials of the battleships were held off Guantanamo last winter, as compared with their trial performances.

With the exception of weakness in the feed pumps and blowers of three of the ships the trials were most satisfactory. Omitting these vessels, the fleet, with an average displacement 830 tons greater than on contract trial, developed an average speed .449 knot greater than the designed speed, and .066 knot greater than the average contract trial speeds.

On these trials the main engines withstood overloads amounting, in the case of one ship, to 40 percent, in excess of the designed load.

An interesting feature, developed by the trials is the improved propeller efficiency of the *Virginia* and *Louisiana,* whose engines were changed from in-turning to out-turning shortly before the trials.

### COMPARISON OF MEASURED-MILE COURSES AT ROCKLAND, PROVINCETOWN AND DELAWARE BREAKWATER.

The Board of Inspection and Survey for Ships has recently held exhaustive comparative trials of the *Michigan, Reid* and *Flusser* over the measured-mile courses at Rockland, Provincetown and Delaware Breakwater, to determine the effect of depth on speed.

The depth on the Rockland course varies from 330 to 480 feet; that at Provincetown from 150 to 160 feet, and at Delaware Breakwater from 135 to 150 feet.

These trials indicate that the *Michigan,* with 16,000 tons displacement and 24 feet 6 inches mean draft, requires about 1,900 less indicated horsepower for a speed of 19 knots on the Rockland course than at the Delaware Breakwater, and somewhat less power for this speed at Provincetown than at the Breakwater. There is a corresponding effect in the case of destroyers. The *Reid,* displacing 700 tons, and with a mean draft of 8 feet ½ inch, requires for a speed of 31 knots about 1,000 less shaft horsepower at Rockland than at the Breakwater, and less at Provincetown than at the course in Delaware Bay.

### REPAIR SHIP.

Our battleship fleet is, to a greater degree than ever before, self-sustaining as regards repairs to engineering material. This is evident in a decreased amount of navy-yard work. The machine-tool equipment of many of the ships has been increased to as great a degree as is possible within the limitations of space available. In some of the ships small cupolas capable of melting 100 pounds of brass and 60 pounds of iron have been improvised, and have proved very valuable for the manufacture of small castings not subject to much stress. A standard oil-burning furnace will be supplied to all the larger ships.

The repair ship *Panther* has rendered most valuable aid to the fleet and has done much of the work heretofore done at the yards.

For times of war, however, when the ability of the fleet to be self-sustaining may be of the utmost strategic importance, our facilities for repairs are hopelessly inadequate. Realizing

this, there have been prepared designs of a proposed repair ship of 13,500 tons displacement and 14 knots speed, with an equipment which will enable it to—

(*a*) Make patterns and castings up to four tons in weight. This includes all iron castings for small vessels, and, in case of a battleship, all except main cylinders and turbine casings. (These, in any event, would be repaired by a welding process.)

(*b*) Forge anything on board ship except main shafting.

(*c*) Roll and bend any plate that may be required for the hull or for boiler drums.

(*d*) Build up lengths of copper piping, and repair and tin defective piping.

(*e*) Do any required machining.

(*f*) Carry all materials for the prosecution of this work.

The proportion of foundry and forge equipment is such as to provide sufficient material for its own machine shop and for the machine shops of all vessels of the fleet. Thus, in emergencies, all the equipment of the individual ships, as well as that of the repair ship, could be run at full capacity.

The design of the repair ship provides for convenient and efficient handling of material progressively from its raw condition through the process of casting, forging and machining in well lighted shops.

The acquisition of such a vessel is of vital military importance to the fleet, in that it will, in time of war, enable the fleet to repair damages sustained in action to a sufficient extent to render it seaworthy and capable of renewing action. In time of war or peace it will render the fleet self-sustaining as regards all repair work to machinery, hull or ordnance equipments, except that necessitated in general refitting.

The experience of the world cruise of the battle fleet demonstrated rather conclusively that extensive cruising does not of itself contribute to deterioration of steam machinery, provided the nature of the cruising is such that fixed periods for periodic overhaul are provided.

It has been too frequently the case that in arranging itineries no attention has been paid to this point, and in many cases commanding officers hesitate at allowing disablement of the main engines for periods greater than twenty-four hours, although such disablement is required in the interests of an efficient maintenance of the plant.

An instance of this has recently developed in the case of two armored cruisers which require such extensive repairs in their engineer department as to render it necessary to lay them up for a period extending over several months. Until these repairs are completed these ships are without strategic value as a component part of the fleet. The present condition of the machinery of these vessels can best be described as generally run down. This is due in great degree to the nature of service to which they have been subjected—extensive cruising with improper spacing of overhaul intervals.

Undoubtedly, our most important duty as regards the machinery of the fleet is that of upkeep—the taking of the proverbial stitch in time which will prevent the accumulation of trouble in such quantities as to disable the fleet as a fighting unit.

This, however, requires co-operation, such as is being accomplished under the present organization.

### BOILERS.

The question of the type of boiler for future battleships is one that is receiving due attention. The present Babcock & Wilcox boiler is giving satisfaction, and that company has recently completed an exhaustive series of tests of a sample boiler for the *Wyoming* and *Arkansas*. In these tests the boiler more than meets every guarantee, and, in fact, attains improved economics of evaporation at all rates of combustion. The boiler stood further test of forcing under five inches of air pressure, burning 70 pounds of coal per square foot of grate surface; all without signs of damage.

Notwithstanding all this, there is a growing sentiment favoring the small-tube express type of boiler for battleships, as giving more elasticity in forcing, especially in a turbine installation, as well as saving weight, on almost the same economy. The Experimental Station at Anapolis has been engaged in research work for more than a year, with considerable success, in an endeavor to determine proper methods and materials for the interior preservation of our boilers. This, of course, is quite essential if we adopt small or bent tubes in boilers.

In-swinging furnace doors have been fitted on all the battleships and are rapidly being installed in other naval vessels. The design of these doors is such as to cause them to close automatically in the event of a ruptured tube. Already, in the *Georgia*, they have prevented serious injury to the fireroom force.

Mosher boilers are being installed in the battleships *Kearsarge, Kentucky* and *Illinois*, to replace their Scotch boilers. The contract for these boilers calls for a guaranteed evaporation of 11¼ pounds of water per hour per pound of combustible at full power, when burning 40 pounds of coal per square foot of grate.

The difficulties heretofore existent with the reciprocating engines of forced-draft blowers have been overcome by the adoption of turbine-driven blowers for destroyers and motor-driven blowers for battleships.

Our new destroyers, propelled by turbines, with liquid fuel and turbine-driven fans, are provided with a machinery installation from which most of the frailties hitherto existent on vessels of this type are eliminated, and which should render them capable of running at full power at any time on demand and for periods limited only by the fuel supply.

Turbine-driven centrifugal feed pumps are being developed and, although at present they are somewhat handicapped by excessive weight and space required, it is probable that these disadvantages will be overcome to a sufficient extent to allow us to show them in new designs. Experience with these pumps in shore plants indicates that they are less prone to disablement than reciprocating pumps.

In conclusion, I will say that engineering in our naval service is to-day in a position more nearly commensurate with its importance to the fleet than seemed possible a few years ago. This is due in part to the enthusiastic efforts of the younger line officers who in recent years have operated our machinery afloat, more to the legacy of experience, ability and good will from the old Engineer Corps, but is principally the result of an appreciation of the importance of engineering on the part of the older officers in the service, who, in responsible administrative positions, both in the Department and in the Fleet, under our able Secretary, are welding the personnel and matériel of engineering into the organization of the fleet in such manner as cannot fail to produce perfect homogeneity.

---

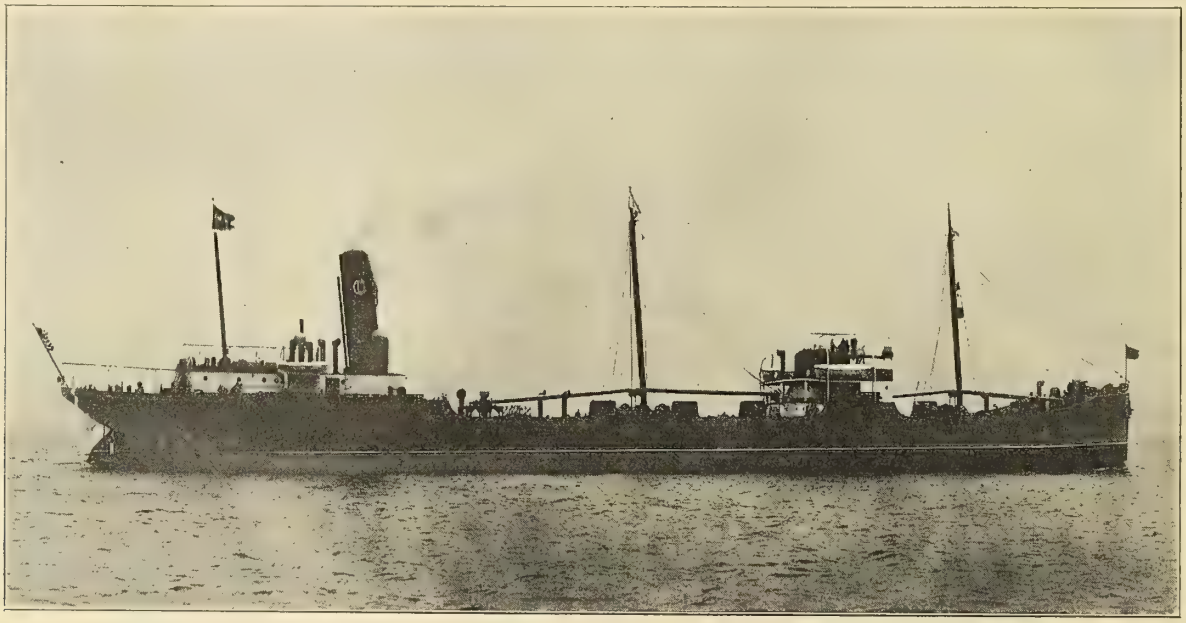
### Lloyd's Annual Report.

According to the annual report of *Lloyd's Register of Shipping*, for the year 1909-1910, classes were assigned to 540 new vessels, the total gross tonnage of which was 929,946. Of this new construction 66 percent was built for the United Kingdom, and 34 percent for the British Colonies and foreign countries. Over 99 percent of the new vessels were steamers. Few features of exceptional interest from the point of view of the designer are mentioned, the most noteworthy being, perhaps, the increase in the number of vessels built on the Isherwood system of longitudinal construction. Up to the present time forty-three vessels of this type have been approved for classification by the society.

## A TANK STEAMER FOR THE MOLASSES TRADE.

There has just been completed at the yards of the Fore River Shipbuilding Company, Quincy, Mass., the steamer *Currier*, named for Mr. Guy W. Currier, of the well-known law firm of Currier, Rollins, Young & Pillsbury, of Boston, and specially designed for the Cuba Distilling Company, of New York, to run between Cuba, Porto Rico and New York in the molasses trade.

The *Currier* is a single-screw steamer with the machinery located aft, constructed of steel to the highest class in Lloyd's Register, being specially surveyed under construction by the officers of that society to obtain the Class 100-A-1, and specially designed to operate in either the molasses, bulk petroleum or general freight trades, a combination rarely met with in vessels of this type. To provide for the safety of the vessel and crew the most modern methods and equipment are employed, including wireless telegraph and submarine signals.



STEAMSHIP CURRIER, BUILT BY THE FORE RIVER SHIPBUILDING COMPANY FOR THE CUBA DISTILLING COMPANY.

The principal dimensions are as follows:

| | |
|---|---|
| Length from fore-side of stem to after-side of rudder post | 370 feet |
| Beam, molded | 52 feet |
| Depth, molded to upper deck | 30 feet |
| Load draft | 23 feet |
| Gross tonnage | 4,711 |
| Net tonnage | 1,841 |

### GENERAL ARRANGEMENT.

The general arrangement and scantlings of the vessel are shown on the accompanying deck plans and section.

She has a straight stem, semi-elliptical stern, two continuous-steel decks, and a full poop, bridge and topgallant forecastle.

Accommodations are provided in the 'midship house for the officers, with saloon, guest room, pantry, bath and toilets, and on the bridge deck is a specially arranged suite of rooms for the captain, having a commodious pilot house and chart house over same. In the 'midship house there is a room fitted up for the wireless telegraph outfit.

The long poop encloses quarters for the firemen, seamen, oilers and petty officers, and in the Liverpool house on the poop deck are arranged the quarters for the engineers, with officers' and engineers' mess, bath and toilet. The crew of the *Currier* comprises forty men.

The general arrangement of the ship consists of five double tanks bounded by transverse and centerline bulkheads, with a general cargo hold forward and aft of these tanks, the machinery being placed right aft and separated from the after cargo hold by a cross bunker. The main tanks are isolated at the forward and after ends by cofferdams extending the full depth of the ship and by a continuous inner bottom 4 feet deep, which is fitted as far forward and aft as practicable. These tanks may be utilized for the transportation of either molasses or bulk petroleum oil, a special pumping system having been installed for loading and discharging liquid cargo, and a steam-heating system for liquefying the cargo as well as to efficiently clean all the spaces by steam.

The total capacity for stowing molasses is 138,000 cubic feet, representing over 1,000,000 gallons of molasses. When used as a bulk petroleum carrier the vessel has a capacity, with oil carried in the tanks and inner bottom, of 1,400,000 gallons, with the usual allowance in the expansion trunk to take up the expansion of the oil.

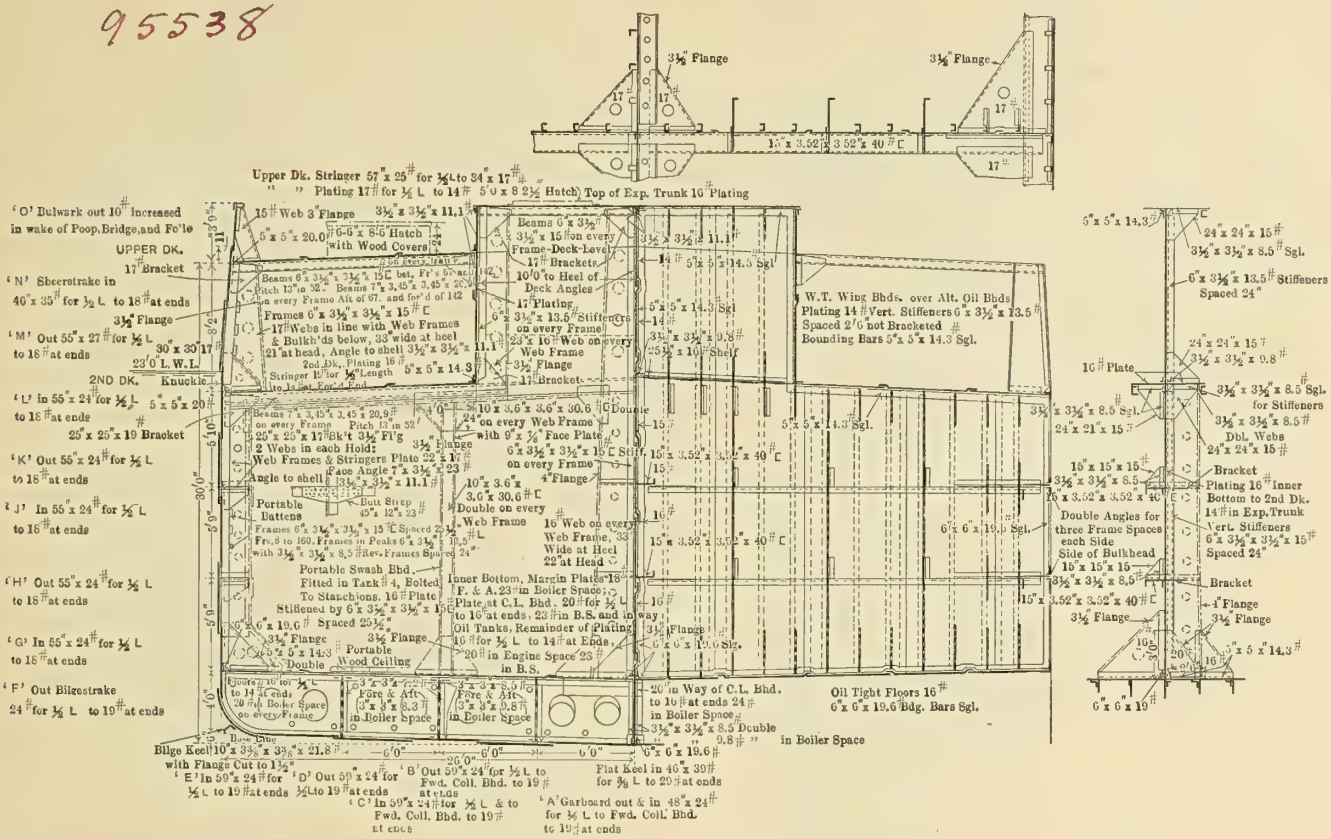
If it is desired to operate this vessel as a general cargo and freight steamer, freight may be carried in the five molasses tanks by removing the portable swash bulkhead, after cleaning out the tanks by steam. The cargo may be handled through steel cargo hatches 8 feet 3 inches by 5 feet. The wing compartments may also be used for freight space, operating through 8 feet 6-inch by 6 feet 6-inch hatches fitted with wooden covers. In addition to this, two large cargo holds occupy the forward and after boundaries of the tanks, these holds having steel cargo hatches 8 feet 6 inches by 20 feet.

The total cargo space avilable for stowage of general freight is about 255,000 cubic feet, and on 23 feet mean draft, with the vessel carrying 1,000 tons of bunker coal, feed water and stores, a dead-weight cargo of 5,800 tons may be carried.

The vessel is rigged with three pole masts, the fore and main mast being of steel and the mizzen mast of wood. The cargo booms consist of four 53-foot and four 40-foot wood derricks, each capable of working a load of 5 tons. A complete suit of sails is provided for the vessel, comprising fore and main sails and stay sails.

The poop deck from the front of house and bridge deck is laid with 3-inch by 5-inch clear, long-leaf yellow pine, having a 10-inch margin plank worked in way of deck house and waterway. The flats of cargo holds are laid out with 2½-

95538

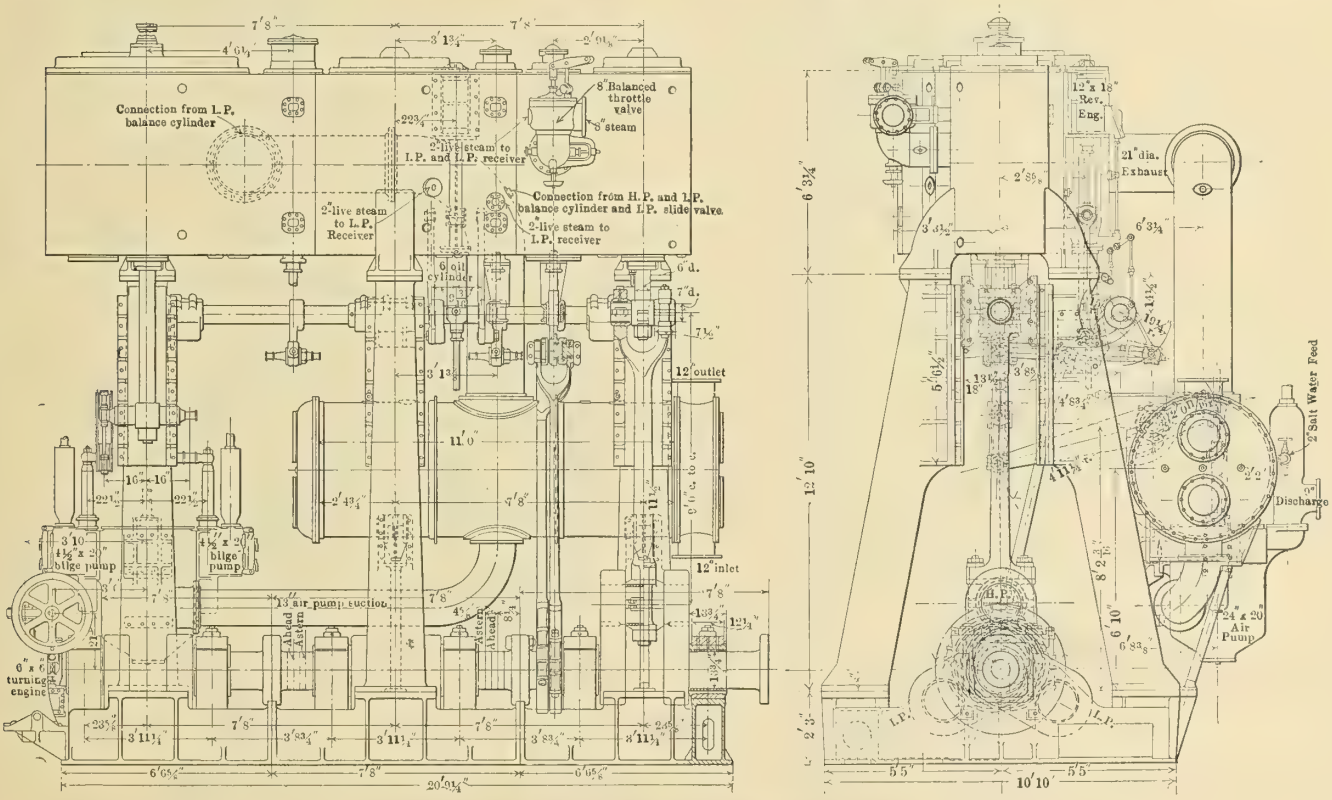

Upper Dk. Stringer 57"x 25# for ½L to 34"x 17#
" " Plating 17# for ½ L to 14# 5'0 x 8 2½ Hatch Top of Exp. Trunk 16# Plating
'O' Bulwark out 10# increased in wake of Poop, Bridge, and Fo'le
UPPER DK.
17# Bracket
'N' Sheerstrake in 46"x 35# for ½ L to 18# at ends
3½" Flange
'M' Out 55"x 27# for ½ L to 18# at ends
30"x 35"17#
23'0" L. W.L.
2ND DK.
Knuckle
'L' In 55"x 24# for ½ L to 18# at ends
5"x 5"x 20#
25"x 25"x 19# Bracket
'K' Out 55"x 24# for ½ L to 18# at ends
'J' In 55"x 24# for ½ L to 18# at ends
'H' Out 55"x 24# for ½ L to 18# at ends
'G' In 55"x 24# for ½ L to 18# at ends
'F' Out Bilgestrake 24# for ½ L to 19# at ends
Bilge Keel 10"x 3⅜"x 3⅜"x 21.8#
with Flange Cut to 1½"
'E' In 59"x 24# for ½ L to 19# at ends
'D' Out 59"x 24# for ½L to 19# at ends
'C' In 59"x 24# for ½ L & to Fwd. Coll. Bhd. to 19# at ends
'B' Out 59"x 24# for ½ L to Fwd. Coll. Bhd. to 19# at ends
Flat Keel in 46"x 39# for ⅜ L to 20# at ends
'A' Garboard out & in 48"x 24# for ½ L to Fwd. Coll. Bhd. to 19# at ends
15# Web 3" Flange
3½"x 3½"x 11.1#
5"x 5"x 20.0#
6'6"x 8'6" Hatch with Wood Covers
Beams 6"x 3½"x 15# bet. Fr's 60" apart
Pitch 13"in 52" Beams 7"x 3.45"x 3.45"x 20.9#
on every Frame Alt. of 67. and for'd of 142
Frames 6"x 3½"x 3½"x 15# C
17# Webs in line with Web Frames
& Bulkh'ds below, 33" wide at heel
21" at head, Angle to shell 3½"x 3½"x 11.1#
2nd Dk., Plating 16#
Stringer E for ½ Length
5"x 5"x 14.3
Beams 7"x 3.45"x 3.45"x 20.9# on every Frame Pitch 13 in 52"
25"x 25"x 17# Bk't 3½" Flg
2 Webs in each Hold
Web Frames & Stringers Plate 22"x 17#
Face Angle 7"x 3½"x 23#
Angle to shell 3½"x 3½"x 11.1#
Portable Battens
Butt Strap 45"x 12"x 23#
Frames 6"x 3½"x 3½"x 15# C Spaced 24"
Frs. 8 to 160, Frames in Peaks 6"x 3½"x 8.5#
with 3½"x 3½"x 8.5# Rev. Frames Spaced 24"
Portable Swash Bhd. Fitted in Tank # 4, Bolted To Starchions, 16# Plate Stiffened by 6"x 3½"x 3½"x 15#
6"x 6"x 19.6# Spaced 25½"
3½" Flange
Portable Wood Ceiling
Doors 10" for ½ L to 19# Ends 20" in Boiler Space on every Frame
3'-3"x 3'-3"x 8.5# Fore & Aft (3'x 3'x 8.3# in Boiler Space)
3'-3"x 3'-3"x 8.5# Fore & Aft (3'x 3'x 8.3# in Boiler Space)
Beams 6"x 3½"x 15# on every Frame-Deck-Level
17# Brackets
10'0" to Heel of Deck Angles
17# Plating
6"x 3½"x 13.5# Stiffeners on every Frame
23"x 10# Web on every Web Frame
3½" Flange
17# Bracket
10"x 3.6"x 3.6"x 30.6# Double on every Web Frame with 9"x ⅜" Face Plate
6"x 3½"x 3½"x 15# C Stiff. on every Frame
4" Flange
10"x 3.6"x 3.6"x 30.6# C Double on every Web Frame
16# Web on every Web Frame, 33" Wide at Heel 22" at Head
Inner Bottom, Margin Plates 18# F. & A. 23" in Boiler Space, Plate at C.L. Bhd. 20# for ½ L to 16" at ends, 23# in B.S. and in way Oil Tanks, Remainder of Plating 16# for ½ L to 14# at Ends, 20# in Engine Space 23# in B.S.
3½" Flange
6"x 6"x 19.6# Sgl.
20" in Way of C.L. Bhd. to 19# at ends 24# in Boiler Space
3½"x 3½"x 8.5# Double " " 9.8# " in Boiler Space
Oil Tight Floors 16# 6"x 6"x 19.6# Bdg. Bars Sgl.
6"x 6"x 19.6#
W.T. Wing Bhds. over Alt. Oil Bhds Plating 14# Vert. Stiffeners 6"x 3½"x 13.5# Spaced 2'6" not Bracketed # Bounding Bars 5"x 5"x 14.3 Sgl.
5"x 5"x 14.3# Sgl.
3½"x 3½"x 11.1#
5"x 5"x 14.3 Sgl.
3½"x 3½"x 9.8#
25½"x 16" Shelf
5"x 5"x 14.3 Sgl.
15"x 3.52"x 3.52"x 40# C
6"x 6"x 19.6# Sgl.
5"x 5"x 14.3#
24"x 24"x 15#
3½"x 3½"x 8.5# Sgl.
6"x 3½"x 13.5# Stiffeners Spaced 24"
24"x 24"x 15#
3½"x 3½"x 9.8#
16# Plate
3½"x 3½"x 8.5# Sgl. for Stiffeners
3½"x 3½"x 8.5# Dbl. Webs
24"x 24"x 15#
24"x 21"x 15#
15"x 15"x 15#
3½"x 3½"x 8.5#
Bracket
Plating 16# Inner Bottom to 2nd Dk. 14# in Exp. Trunk
Vert. Stiffeners 6"x 3½"x 3½"x 15# Spaced 24"
Double Angles for three Frame Spaces each Side Side of Bulkhead
15"x 15"x 15#
3½"x 3½"x 8.5#
15"x 3.52"x 3.52"x 40# C
3½" Flange
Bracket
4" Flange
3½" Flange
16"
20"
16"
5"x 5"x 14.3#
6"x 6"x 19#

MIDSHIP SECTION OF THE CURRIER.

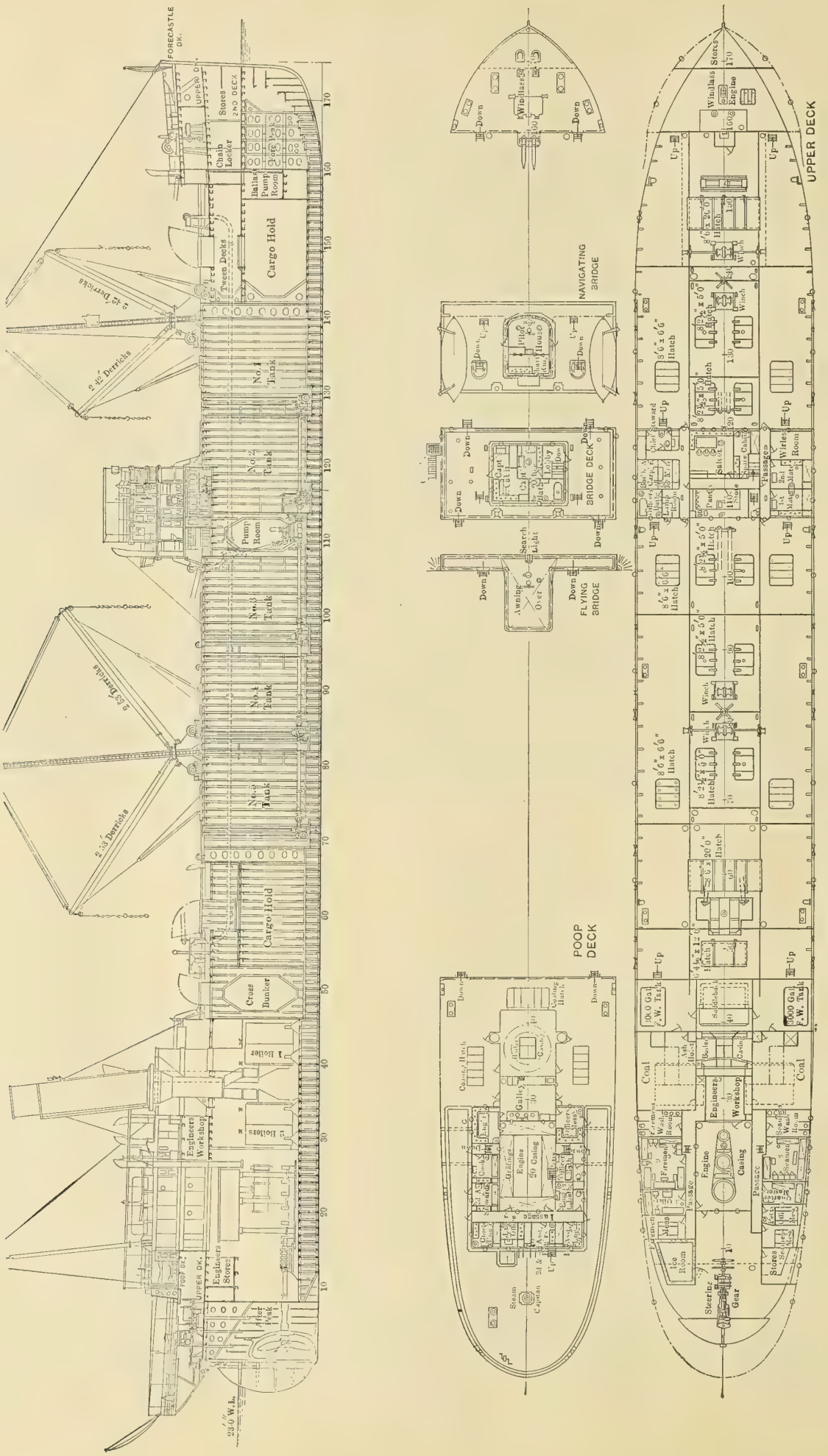
inch yellow pine ceiling in portable shutters, and portable sparring is fitted for sides of vessel for general cargoes.

The joiner work and furniture in quarters is finished generally in oak. Transoms and seats are upholstered in leather. The floors in officers' quarters are covered with linoleum. The galley floor is laid in unfinished red tile, and the bath rooms in ceramic tile. The pilot-house and chart room are built of teak.

The sanitary arrangements are very complete, flowing water being supplied to all fixtures. The salt water is kept under pressure by a salt-water sanitary pump, while the fresh water




MAIN ENGINES OF THE CURRIER, SHOWING CONDENSER AND PUMP CONNECTIONS.




INBOARD PROFILE AND DECK PLANS OF THE TANK STEAMER CURRIER.

flows by gravity from a daily service tank supplied by the fresh-water sanitary pump. The officers' lavatories are supplied with hot as well as cold water.

In addition to the usual ventilators for the engine-room and fire-room, of which there are two 21-inch for the former and two 36-inch for the latter, at each cargo hold, there are installed four 18-inch ventilators and two for the pump-room. Cast iron swan-neck ventilators are also fitted on top of expansion trunks.

The life-saving outfit consists of two 24-foot wooden lifeboats, one 16-foot wooden dinghy and one 20-foot wooden gig, fitted with gasoline engine. The lifeboats are handled by the ordinary round-bar davits, and the dinghy and gig handled by davits of the Mallory type.

### DECK MACHINERY.

The steering gear is of the Hyde steam screw gear type, with an 8-inch by 8-inch engine, operated through shafting and bevel gears from steering stands in the pilot house on the flying bridge and top of the after-house. Hand wheels for hand steering are direct connected to screw gear in after steering compartment. An emergency steering gear is fitted, by which the vessel may be steered by a tackle leading from a spare tiller to a steam capstan on the poop deck.

A No. 10 Hyde steam brake windlass is located on the forecastle deck, operated by a worm and spindle from a vertical engine on upper deck. The wildcats on the windlass are suitable for 2⅛ inches diameter stud link cable. Large quick operating warping ends are fitted on each side of the windlass.

Four Hyde double drum, double cylinder, reversible steam hoisting winches with cylinders 8 inches diameter by 8 inches stroke are located on deck, for cargo handling purposes. Two of these winches are fitted with extended warping ends.

A Hyde reversible steam capstan of the quick warping type is located aft on the poop deck, operated by an 8-inch by 8-inch engine under the deck.

### PUMPING SYSTEM.

The pumping system on the *Currier* for handling liquid cargo was especially designed for pumping heavy viscous liquids such as molasses or oil. The cargo pump is of the Blake horizontal duplex piston type, with steam cylinder 16 inches diameter, pump cylinder 12 inches diameter with 18-inch stroke.

A 14-inch suction main of wrought iron extends through the cargo holds on the port side above the innner bottom, with 12-inch branches extending into suction wells in each tank, each branch being fitted with a brass gate valve and bell mouth suction end.

A 10-inch discharge main of wrought iron pipe extends through the wing compartments below the main deck, on each side with branches leading to each tank, and to overboard discharge connections, forward, amidships and aft.

Sluice valves are fitted in the centerline and transverse bulkheads dividing the main holds, so that the cargo may be trimmed the full length of hold spaces.

The entire system is so arranged that the cargo pump can pump from the cargo tanks and discharge overboard, from storage tanks on shore direct to the cargo tanks, from any cargo tank to any other, from sea to any cargo tank for ballast purposes. The tanks may also be filled through the discharge main.

The vessel is designed primarily to carry molasses in bulk, in which case the double bottom in way of cargo tanks is used for water ballast. In the event of the vessel carrying oil in bulk, the double bottom manhole covers are removed and the double bottom compartments used as a part of the oil cargo space. Portable bolted plates are fitted in the bottom of all molasses suction wells, so that when the vessel is to carry oil these plates may be removed and an extension piece attached to each suction branch, thereby making the branch sufficiently long to pump oil from double bottom compartments.

The forward ballast system consists of a steam pump located in the forward pump room, with a manifold having connections to sea, bilge and forward double bottom compartments.

The after ballast system consists of a steam pump in the engine room, with manifolds having connections to sea, bilges and double bottom. The double bottom compartments under the molasses tanks are so arranged that they may be entirely cut off from the remainder of the ballast system.

The electric lighting plant consists of one 15 kilowatt direct connected General Electric Co. marine generating set, with combined generating and distributing switchboard. The distribution is on the two-wire system and supplies current for one 18-inch searchlight and 150 16-candlepower incandescent lamps in addition to running and signal lights.

The wireless telegraph outfit supplied by the United Wireless Company is installed in the bridge house. In addition, the receiving apparatus of the Submarine Signal Company is provided, nothing having been omitted which would add to the comfort or safety of the vessel or crew.

### PROPELLING MACHINERY.

The propelling machinery, located in the stern of the ship, consists of a vertical inverted, three-cylinder, triple expansion engine with cylinders 25-41-68 inches diameter having a stroke of 48 inches, supplied with steam at 190 pounds pressure by three single-ended Scotch boilers working under a heated forced draft system.

The bedplate of the main engine is of the usual box section type of cast iron in three sections, having six main bearings of cast iron lined with white metal. Bearing caps are forged steel. All lower main bearings may be removed while the crank shaft is in position.

The cylinders are supported by six cast iron columns of box section, three front and three back. All crosshead guides are fitted for water circulation.

The crankshaft is of the built-up type, of forged steel throughout, in three interchangeable reversible sections. The diameter of the shaft at the bearings is 13¾ inches. The crank pins are 14 inches diameter by 14 inches long, the crank slabs 25¾ inches wide by 9½ inches thick, and all couplings are 27 inches diameter 3¼ inches thick, joined by six steel bolts.

The cylinders are arranged, beginning at the forward end of the engine, high-pressure, intermediate-pressure and low-pressure. The high-pressure cylinder is fitted with a liner, and the valve is of piston type, 13 inches diameter, taking steam in the middle and exhausting over the ends. The intermediate and low-pressure cylinders are fitted with double ported slide valves working on cast iron false seats. All valves are fitted with balance cylinders for taking weight of valves and gear. In addition, the intermediate-pressure and low-pressure slide valves are fitted with balance rings on the back for relieving pressure on valve seat.

The pistons are of conical form, the high-pressure is of cast iron, while the intermediate-pressure and low-pressure are cast steel. All pistons are fitted with Mudd's rings and cast iron followers. The piston rods are 6 inches diameter, the low-pressure being fitted with a tail rod, 4 inches diameter. Piston rods and valve stems are packed with metallic packing. The forged steel crossheads are secured to the piston rods by steel nuts, the lower ends of the rods being tapered to fit the crossheads. Crosshead slippers are cast iron faced with white metal and crosshead pins are 7 inches diameter and 7½ inches long. The connecting rods are forged steel, 9 feet between centers. The top and bottom end boxes are cast steel lined

with white metal, the caps being secured by forged steel binders. The valve gear is of the usual Stephenson double bar link gear type.

An 8-inch balanced throttle valve worked by a hand wheel, and a butterfly valve worked by a hand lever, control the supply of steam to the high-pressure valve chest. The receivers are cast with the cylinders. The main exhaust pipe to the condenser is of copper, 21 inches diameter.

The reversing gear consists of a direct acting steam cylinder, 12 inches diameter and 18 inches stroke, secured to the back of the intermediate-pressure cylinder. A reverse shaft, 6½ inches diameter, carried in bearings at the back of the engine, transmits motion from the reverse engine to the links. The cut-off of each valve may be adjusted separately by means of a sliding block working in slotted reverse shaft arms. Smooth action of the reversing engine is secured by a 6-inch diameter piston working in a hydraulic cylinder.

A 6-inch by 6-inch single cylinder turning engine is secured to the after end of the main engine bedplate.

The thrust shaft is 13¾ inches diameter, with nine collars 20 inches diameter, 1⅞ inches thick, forged solid with the shaft. The propeller shaft is 14¾ inches diameter, protected throughout its entire length by composition sleeves shrunk and pinned in place. The propeller is secured to the tapered end of the shaft by a forged steel nut and feather. All shaft couplings are 26 inches diameter 3¼ inches thick, connected by six forged steel bolts 3¼ inches diameter.

The thrust bearing is of the usual horseshoe type having nine adjustable cast iron horseshoes faced with white metal. Each shoe may be adjusted separately, while the entire bearing may be moved fore and aft by means of wedges. The bottom of the pedestal forms an oil chamber into which the collars project. The stern tube bearings are of composition lined with lignumvitae.

The propeller is of the built-up type 16 feet 9 inches diameter, 18 feet pitch, 92.3 square feet developed area, having four adjustable bronze blades secured to a cast iron hub by bronze studs and nuts. The pitch may be adjusted from 17 feet to 19 feet.

AUXILIARIES.

The air pump is of the Edwards type, 24 inches diameter, 20-inch stroke, driven by beams and links from the low-pressure crosshead. The body of the pump is cast iron having a composition liner.

The condenser, placed on brackets at the back of the engine, has a cylindrical steel plate shell with cast iron water chests and covers. There are 1394 ¾-inch brass tubes, 11 feet long, between tube sheets, giving a cooling surface of 3011 square feet. The tube ends are packed in the usual manner with cotton wicking secured by brass glands screwed into rolled composition tube sheets. Circulating water for the condenser is taken from a centrifugal pump of the Fore River type having 12-inch suction discharge. The pump, driven by an 8-inch by 8-inch vertical engine, has the following connections: Suction from sea, and discharge overboard through condenser, also a small connection is fitted to the evaporator.

The following additional pumps are fitted:

Two feed 10-inch by 7-inch by 10-inch vertical duplex Worthington Admiralty type, with suctions from sea, after tank, auxiliary condenser, feed tank and boilers and discharge through the feed-water heater or direct to the boiler through the main or auxiliary feed line, or overboard. The connections are such that either pump can be used independently of the other. When acting as feed pumps they are automatically controlled by a float in the feed tanks.

One ballast, 10-inch by 12-inch by 10-inch vertical duplex, with suction from sea, bilge manifold, ballast manifolds, and from engine and fire-room bilges, and discharge to fire main, ballast manifolds and overboard.

One forward ballast system pump, 8-inch by 8½-inch by 12-inch horizontal duplex.

Two bilge pumps, 4½-inch by 20-inch plunger type, connected to the main air pump crosshead, have suction from the engine and fire-room bilges and bilge manifolds, with discharge overboard.

One salt-water deck service and fire pump, 6-inch by 4-inch by 6-inch horizontal duplex, with suction from sea and discharge to the sanitary system, fire main, deck-washing pipe and engine-water service. This pump is interchangeable with the auxiliary condenser circulating pump.

One fresh-water, 3½-inch by 4-inch by 4-inch horizontal duplex, with suction from fresh-water tanks and discharge to ship's fresh-water system.

One auxiliary condenser circulating, 6-inch by 4-inch by 6-inch, with suction from sea, discharge end of condenser and after tank, and discharge through the auxiliary condenser overboard and deck-service lines.

One cargo pump, 16-inch by 12-inch by 18-inch horizontal duplex.

One 2-inch Hancock injector is fitted, with suction from the reserve feed tank auxiliary condenser and sea discharge to the auxiliary feed line and hose connection.

The vessel is fitted with one double circular stack, 9 feet 6 inches outside diameter and about 80 feet high above the grates.

The boilers are 13 feet 9 inches mean diameter and 11 feet 1 inch long over the heads, arranged in a single fire room. Each boiler has three Morison furnaces, 42 inches inside diameter and three combustion chambers. The tubes are 2½ inches outside diameter. The total heating surface for three boilers is 6,501 square feet, with 154.5 square feet of grate, giving a ratio of about 42 to 1. The grates are about 5 feet long.

Air for the heated forced draft is delivered to the furnaces by a fan located in the fire room and driven by a 6-inch by 5-inch vertical engine working at a steam pressure of 125 pounds. The fan is 84 inches diameter, and at 312 revolutions per minute delivers 24,000 cubic feet of air per minute at a pressure of 3 inches of water. On each uptake there is a heater box containing 193 3¼-inch tubes 3 feet 6 inches long, around which the air passes before entering the furnaces.

An auxiliary condenser containing about 400 square feet of cooling surface is located in the engine room. Circulating water for this condenser is taken from the ballast and sanitary pumps.

A feed-water heater of the Quiggins vertical type is located in the engine room on the discharge side of the feed pumps. The heater has a rated capacity of 2,700 horsepower.

All living quarters of the ship are heated by steam. Radiators constructed of iron pipe are used throughout the ship except in the pilot house, where brass pipe is used.

One 25-ton evaporator of the Blake type is installed in the after end of the engine room. Steam for operating is taken from the auxiliary steam line and the vapor is discharged to the condenser, feed tank, and after tank.

The refrigerating plant consists of a 2-ton Brunswick ammonia compressor, driven by a vertical engine.

Both fire-room ventilators are fitted with sheaves for hoisting ashes. A Hyde double-cylinder ash-hoist engine is fitted for raising ashes to the spar deck, where they are handled on trolley ways on each side of the ship. A hand ash-hoist gear is also fitted.

During the four-hour trial the ship averaged a little over 10½ knots.

## COLUMN TABLES FOR SHIP WORK—III.

BY R. EARLE ANDERSON.

### EFFECT OF FORM AND THICKNESS.

The relative dimensions and the form of parts composing the cross-section of a column must necessarily have a considerable influence upon its strength. The matter is one which has rested largely upon the judgment of the designer, and there is an almost entire absence of data, either experimental or theoretical, throwing any light on the subject. All accepted column formulas, including those dealt with in the proceeding sections, contain the area of the section and the radius of gyration, and in some cases the distance to the extreme fiber appears in a secondary manner. No other functions of the cross-section appear. To a person devoid of judgment it would seem that the greater the radius of gyration the smaller might be the area, even to the extent of a radius of gyration approaching infinity with an area approaching zero. Thus, in the case of a tubular column, there is nothing in the formulas to indicate that the efficiency cannot be indefinitely increased by making the diameter very great and the thickness of wall an inappreciable quantity. This is, of course, absurd, but the limit below which it is rational and above which it is absurd unfortunately remains undetermined.

In the case of compression members built of plates and angles or otherwise having webs and flanges there are two rules in existence, both of which appear to be entirely empirical. Johnson's "Framed Structures" (chapter by C. W. Byran) gives a rule for box or latticed columns that when pin-connected the thickness of the web plates normal to the pin should be not less than one-thirtieth the distance between the lines of rivets, and the thickness of the plates parallel to the pin should be not less than one-fortieth the distance between rivets; in the case of square or fixed ended columns both thicknesses are limited to one-thirtieth (Framed Structures, page 253). This rule appears to be based upon Bouscaren's experiments (Trans. Am. Soc. C.E., Vol. IX., page 452).

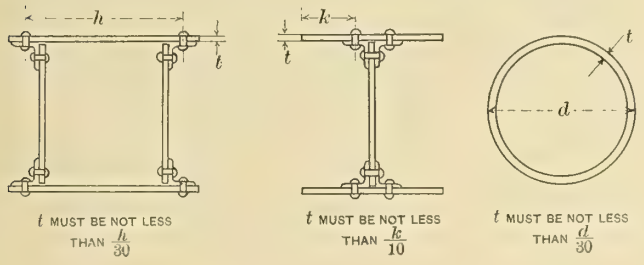



FIG. 4.

The American Railway Engineering and Maintenance of Way Association limits the ratio of unsupported width of outstanding parts to ten times the thickness of metal.

While these two rules are empirical and apparently rest more upon a basis of judgment than experiment, they have evidently been acceptable, and have given satisfactory results. For the present purpose they may be stated thus:

In the cross-section of a compression member the thickness of each part must be at least one-thirtieth the breadth of that part between supporting parts, and in the case of outstanding parts at least one-tenth the outstanding breadth (see Fig. 4).

It will be observed that neither of these rules is applicable to a tubular column.

As previously stated, a series of experiments has been made by Prof. W. L. Lilly on the effect of secondary flexure or wrinkling on the strength of columns, with a view to determining the relation between the strength of a column and the form and relative dimensions of its cross-section.

These experiments are at present only partially complete and have so far been applied only to certain elementary forms. He obtains a formula for the limiting stress, which contains the thickness and a constant, the latter depending on the form of the cross-section and on the material. This formula expresses the limiting load on a column of one wave length (i. e., the length of one wrinkle of the secondary flexure) and is as follows:

$$p = \frac{f}{1 + k\frac{r}{t}}$$

where $k$ is some constant and $t$ is the thickness. This formula has a rational basis but rests upon empirical constants. The rational basis is practically that of Rankine's formula.

He also states that $k$ takes the form $Nf/E$, where $N$ is a constant depending only on the form of the section.

He gives the values of $N$ as follows:

for ○ section, $N = 50$
for □ section, $N = 60$
for + section, $N = 120$
for △ section, $N = 80$
for I section, $N = 70$

(Note.—In *London Engineering* these values of $N$ are incorrectly given and are corrected in the pamphlet *The Design of Columns and Struts.*)

Dr. Dilly then puts this limiting stress into Rankine's formula, with the following result:

$$p = \frac{f}{1 + K\frac{r}{t} + C\frac{l^2}{r^2}}$$

where $C$ is an additional constant. He goes to considerable length to show that this formula is rational, but it is to be noted that not only $C$ and $K$ are empirically evaluated, but $f$ also.

In the usual form of Rankine's formula $f$ is taken as about two-thirds of the ultimate tensile strength. Dr. Lilly, in his proposed formula, takes $f$ as something greater than the ultimate tensile strength, observing that his tests for $l/r$ close to zero show a value of the average unit stress exceeding the tensile strength. The values of the other constants, therefore, rest upon this assumption. While Dr. Lilly's tests are by no means the only ones which show a high value of $p$ at $l/r$ nearly zero, other tests, notably those of Tetmajer and Marshall, made for the specific purpose of evaluating $f_t$, do not show such high values.

The objections raised against Rankine's formula apply equally to Dr. Lilly's in the form in which he proposes it, and it should be noted that the formula contains no factor for inherent eccentricity.

It is interesting now to compare Dr. Lilly's expression for the limiting strength with the results of the tests made at the Norfolk Navy Yard. For 2½-inch by ⅛-inch tubing, with an ultimate tensile strength of 65,500 pounds, we have by Lilly's formula, for the limiting compression stress on a column of at least one wave length (using $f = 80{,}000$ and $K = \frac{1}{8}$, as given by Lilly):

$$p = 45{,}600.$$

The highest observed stress on this tubing was about 69,000 pounds per square inch (for $l/r = 2\frac{1}{2}$), and wrinkling occurred at an average unit stress of 66,000 pounds at $l/r = 13$. For 1¾-inch by ⅛-inch tubing, with an ultimate tensile strength of 60,000 pounds, we have by Lilly's formula:

$$p = 54{,}300.$$

The highest observed stress was 79,000, with wrinkling occurring at 75,000 at $l/r = 13$.

In the case of the Watertown tests referred to in Section VI (*Eng. News*, Aug. 26, 1909), the tubes were 5 inches by 0.36 inch. By Lilly's formula the limiting stress for a tube of one wave length would be

$$p = 54{,}400;$$

while for $l/r = 12\frac{1}{2}$ the Watertown tests ran as high as 60,000 pounds per square inch.

In view of the above it does not seem best to accept the formula proposed by Dr. Lilly at the present time, and it is unfortunate that the results of his experiments have not been interpreted by means of some formula more closely in accordance with general experimental data and more strictly rational than Rankine's. It should be noted also that the formula does not lend itself to tabulation.

Use may be made of the formula, however, for determining a rule for limiting the thinness of tubular columns.

Assuming that wrinkling occurs when the average stress is equal to the elastic limit (inspection of the Watertown tests cited above seems to bear out this assumption) and that the elastic limit is $ft/2$, we would have for $r/t$ the value 8. If we take $f$ as 80,000, as given by Lilly, and put $p = 30{,}000$ for the elastic limit, we have $r/t = 13$. It would seem reasonable to take the limiting value of $r/t$ as 10, and this will cause no serious hindrance in reasonable proportioning.

The radius of gyration of a tube is:

$$r = \frac{1}{4}\sqrt{d^2 + d_1^2}$$

For a thin tube no great error is made if the inside and outside diameters be taken as equal, so that we may write:

$$r = \frac{d}{4}\sqrt{2} = 0.354\,d$$

Expressing $t$ in terms of $d$ then, instead of in terms of $r$, we have for $r/t = 10$, the corresponding value $d/t = 28.3$, which, to bring an even figure, may be called 30.

The following rule is, therefore, proposed for the thickness of tubular columns and struts:

*The thickness of wall must be not less than one-thirtieth the diameter.*

CONSTRUCTION OF THE TABLES.

In applying Moncrieff's formula to a given material, the two properties of the material which are used are the modulus of elasticity and the ultimate compressive strength.

For wrought iron, and the various classes of steel, the ultimate compressive strengths have been taken as equal to the corresponding tensile strengths and the commonly accepted values of the modulus of elasticity have been used, namely, 28,000,000 for wrought iron and 30,000,000 for steel. There is no sufficient evidence to show that the modulus of elasticity for steel varies with the tensile strength or with the chemical composition; in fact, abundant authority may be cited to the contrary. The actual tensile strengths used correspond to those required by the navy specifications.

For the compositions (brasses and bronzes) the ultimate compressive strengths were also taken as equal to the corresponding tensile strengths; and as no very definite strength classifications exist for these materials, the three values of 40,000 pounds, 60,000 pounds and 80,000 pounds were taken as about covering the range of tensile strengths obtainable with the various compositions, the unit column strengths for other values of the tensile strength being obtainable from the tables by interpolation. The modulus of elasticity varies somewhat for the various compositions and is not as definitely determined as for steel. The value 13,000,000 was used as fairly well representing all classes of composition, this being a conservative figure based upon a careful examination of the test data published by Prof. R. T. Thurston, "Materials of Engineering, Part III, Brasses, Bronzes and Other Alloys." These tests are a part of a very full investigation made by the Committee on Metallic Alloys of the United States Board appointed to test iron, steel and other metals. So far as the writer has been able to discover, there are no published test data for composition columns. The broad experimental basis of Moncrieff's formula allows us, however, to extend it to this class of material with a reasonable degree of confidence.

In the case of the various kinds of wood the ultimate compressive strengths are much less than the corresponding tensile strengths, and the compressive strengths themselves have therefore been used. The values employed for the ultimate compressive strength and the modulus of elasticity are as follows:

| | Ultimate Compressive Strength. | Modulus of Elasticity. |
|---|---|---|
| White pine | 5,400 | 1,400,000 |
| Douglas fir (Oregon pine) | 5,700 | 1,700,000 |
| Spruce and ash | 7,200 | 1,600,000 |
| Yellow pine | 8,000 | 2,000,000 |
| Oak | 8,500 | 2,000,000 |

These figures are based upon tests made for the Department of Agriculture by Prof. J. B. Johnson (see U. S. Forestry Circular No. 15 and Johnson's Materials of Construction, pp. 671). They are strictly applicable only to timber having a "standard moisture" of 12 percent—that is, for timber thoroughly seasoned—and consequently for timber less well seasoned a proper allowance should be made in the factor of safety. Green timber may be expected to show about half the strength indicated in the tables.

In Fig. 5 are shown curves plotted from Moncrieff's formula for the various classes of steel, wrought iron and composition. It will be seen from these curves that for the lower values of $\frac{l}{r}$ the value of $ft$ has a considerable influence, while for the higher values of $\frac{l}{r}$ the controlling factor is the modulus of elasticity. The result of this is that for values of $\frac{l}{r}$ less than, say, 100 there is an appreciable advantage obtained by using a material of high tensile strength, while beyond 100 this advantage rapidly diminishes and finally becomes inappreciable.

It will also be seen that the low value of the modulus of elasticity of composition causes its strength to fall off very rapidly as $\frac{l}{r}$ increases, so that as compared with steel of equal tensile strength the strength of brass or bronze columns may be only about one half that of the stiffer material for usual values of $\frac{l}{r}$. This is an important fact that is perhaps little appreciated.

It is desirable to point out that the use of the Construction and Repair tables will lead to no very great change in practice except as they give information for classes of material for which column data have not before been presented in sufficiently convenient form to permit of general use. In Fig. 6 is shown a curve plotted from these tables for the safe unit load for columns of 60,000 pound steel with a nominal safety factor of 4, in comparison with a number of other accepted working formulas placed as nearly as practicable upon the same basis. The great diversity of results obtainable from these various formulas is again illustrated in this figure, but it will be seen that the curve representing the Construction and Repair tables,

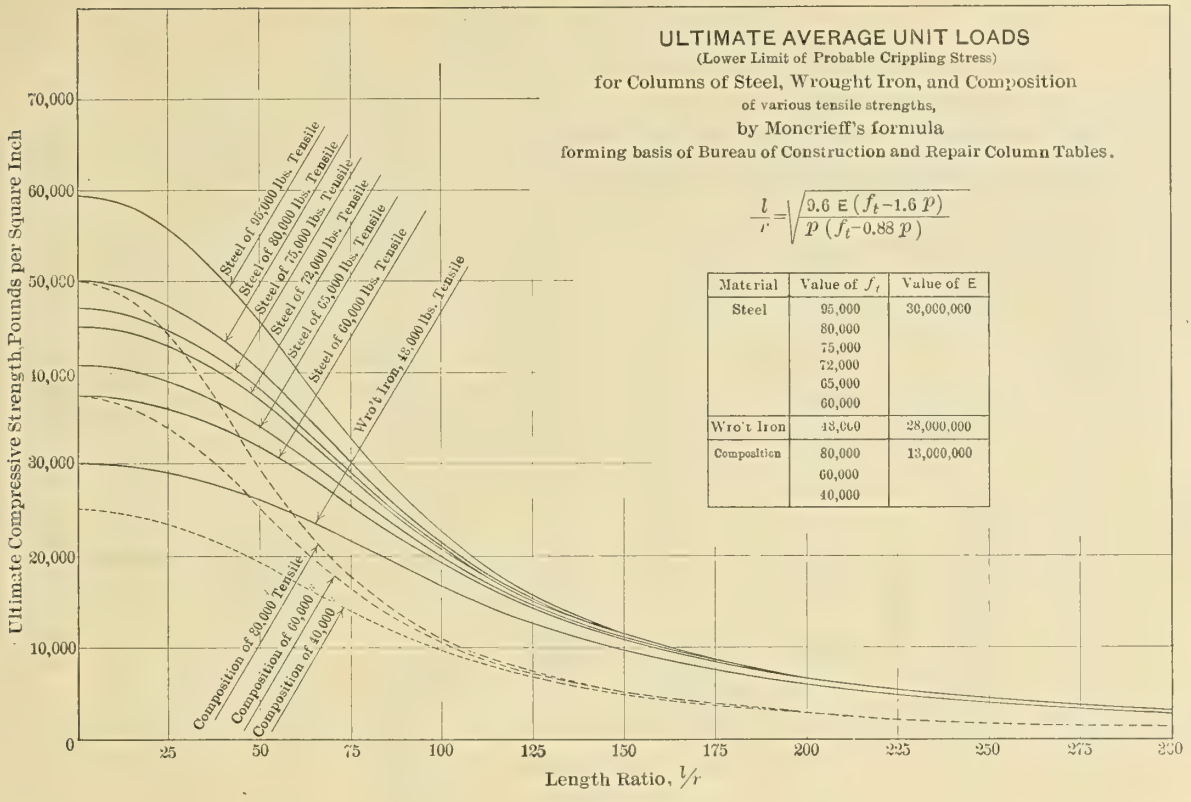

ULTIMATE AVERAGE UNIT LOADS
(Lower Limit of Probable Crippling Stress)
for Columns of Steel, Wrought Iron, and Composition
of various tensile strengths,
by Moncrieff's formula
forming basis of Bureau of Construction and Repair Column Tables.
$\frac{l}{r}=\sqrt{\frac{9.6\ E\ (f_t-1.6\ p)}{p\ (f_t-0.88\ p)}}$
Material | Value of $f_t$ | Value of E
Steel | 95,000 | 30,000,000
80,000
75,000
72,000
65,000
60,000
Wro't Iron | 48,000 | 28,000,000
Composition | 80,000 | 13,000,000
60,000
40,000
Steel of 95,000 lbs. Tensile
Steel of 80,000 lbs. Tensile
Steel of 75,000 lbs. Tensile
Steel of 72,000 lbs. Tensile
Steel of 65,000 lbs. Tensile
Steel of 60,000 lbs. Tensile
Wro't Iron, 48,000 lbs. Tensile
Composition of 80,000 Tensile
Composition of 60,000
Composition of 40,000
Ultimate Compressive Strength, Pounds per Square Inch
Length Ratio, $l/r$

FIG. 5.

while somewhat conservative, lies within the field occupied by the other formulas. The fact that it most nearly corresponds to the Pencoyd curve is significant, inasmuch as the Pencoyd curve is based solely upon tests without the intervention of any formula, either empirical or rational. The correspondence would be still closer were it not for the fact, already

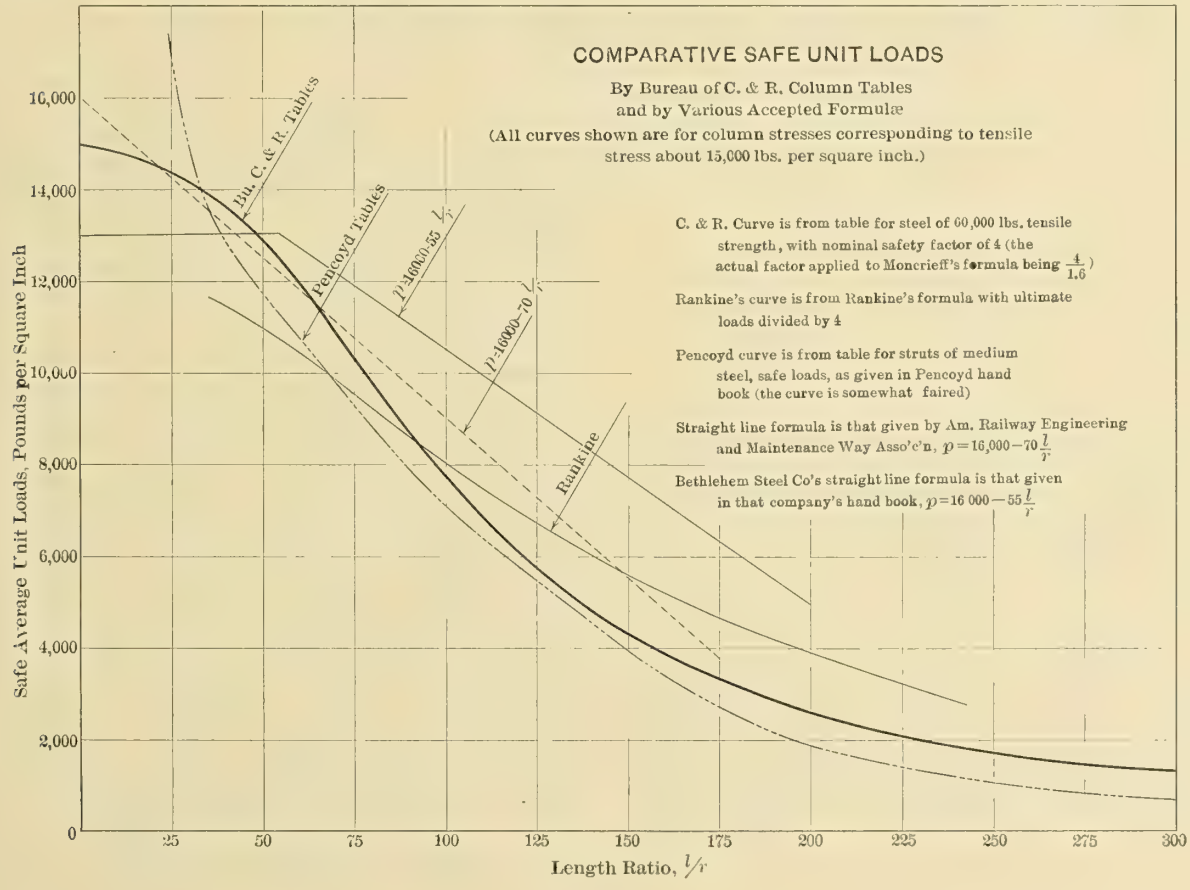

COMPARATIVE SAFE UNIT LOADS
By Bureau of C. & R. Column Tables
and by Various Accepted Formulæ
(All curves shown are for column stresses corresponding to tensile
stress about 15,000 lbs. per square inch.)
C. & R. Curve is from table for steel of 60,000 lbs. tensile strength, with nominal safety factor of 4 (the actual factor applied to Moncrieff's formula being $\frac{4}{1.6}$)
Rankine's curve is from Rankine's formula with ultimate loads divided by 4
Pencoyd curve is from table for struts of medium steel, safe loads, as given in Pencoyd hand book (the curve is somewhat faired)
Straight line formula is that given by Am. Railway Engineering and Maintenance Way Asso'c'n, $p=16{,}000-70\frac{l}{r}$
Bethlehem Steel Co's straight line formula is that given in that company's hand book, $p=16\,000-55\frac{l}{r}$
Bu. C. & R. Tables
Pencoyd Tables
$p=16000-55\ l/r$
$p=16000-70\ l/r$
Rankine
Safe Average Unit Loads, Pounds per Square Inch
Length Ratio, $l/r$

FIG. 6.

ULTIMATE LOADS PER SQUARE INCH.

(Lower Limit of Probable Crippling Stress.)

For Safe Loads, divide values given in table by six-tenths of nominal safety factor.

| $\frac{l}{r}$ | Wrought Iron 48,000 Pounds Tensile Strength. | Steel of 60,000 Pounds Tensile Strength. | Steel of 65,000 Pounds Tensile Strength. | Steel of 72,000 Pounds Tensile Strength. | Steel of 75,000 Pounds Tensile Strength. | Steel of 80,000 Pounds Tensile Strength. | Steel of 95,000 Pounds Tensile Strength. | Composition of 40,000 Pounds Tensile Strength. | Composition of 60,000 Pounds Tensile Strength. | Composition of 80,000 Pounds Tensile Strength. | White Pine. | Douglas Fir (Oregon Pine). | Spruce and Ash. | Yellow Pine. | Oak. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 29,100 | 36,100 | 39,050 | 43,100 | 44,750 | 47,600 | 55,950 | 23,600 | 34,300 | 44,300 | 3,130 | 3,350 | 4,120 | 4,630 | 4,890 |
| 30 | 28,660 | 35,500 | 38,350 | 42,200 | 43,800 | 46,500 | 54,320 | 23,000 | 32,900 | 41,800 | 3,020 | 3,250 | 3,960 | 4,470 | 4,710 |
| 35 | 28,100 | 34,800 | 37,500 | 41,100 | 42,660 | 45,200 | 52,500 | 22,250 | 31,280 | 39,100 | 2,900 | 3,130 | 3,760 | 4,280 | 4,500 |
| 40 | 27,480 | 34,000 | 36,500 | 39,900 | 41,300 | 43,700 | 50,500 | 21,400 | 29,450 | 36,050 | 2,760 | 3,000 | 3,550 | 4,060 | 4,250 |
| 45 | 26,810 | 33,100 | 35,330 | 38,600 | 39,850 | 42,000 | 48,350 | 20,460 | 27,460 | 32,800 | 2,610 | 2,850 | 3,320 | 3,830 | 4,000 |
| 50 | 26,090 | 32,100 | 34,100 | 37,100 | 38,250 | 40,230 | 45,950 | 19,440 | 25,450 | 29,800 | 2,450 | 2,700 | 3,080 | 3,580 | 3,730 |
| 55 | 25,330 | 31,000 | 32,800 | 35,500 | 36,550 | 38,330 | 43,400 | 18,360 | 23,450 | 26,930 | 2,270 | 2,540 | 2,850 | 3,320 | 3,460 |
| 60 | 24,520 | 29,700 | 31,400 | 33,700 | 34,750 | 36,400 | 40,700 | 17,260 | 21,500 | 24,250 | 2,110 | 2,380 | 2,620 | 3,080 | 3,180 |
| 65 | 23,680 | 28,500 | 30,000 | 32,050 | 33,000 | 34,300 | 38,000 | 16,160 | 19,700 | 21,850 | 1,950 | 2,220 | 2,400 | 2,840 | 2,930 |
| 70 | 22,780 | 27,100 | 28,500 | 30,350 | 31,100 | 32,200 | 35,400 | 15,090 | 18,000 | 19,700 | 1,800 | 2,060 | 2,190 | 2,620 | 2,680 |
| 75 | 21,840 | 25,800 | 27,050 | 28,700 | 29,300 | 30,150 | 32,950 | 14,050 | 16,400 | 17,800 | 1,660 | 1,910 | 2,000 | 2,400 | 2,460 |
| 80 | 20,850 | 24,400 | 25,530 | 27,100 | 27,500 | 28,200 | 30,600 | 13,050 | 15,000 | 16,080 | 1,530 | 1,770 | 1,830 | 2,210 | 2,260 |
| 85 | 19,800 | 23,100 | 24,000 | 25,450 | 25,750 | 26,400 | 28,350 | 12,100 | 13,700 | 14,500 | 1,410 | 1,630 | 1,680 | 2,030 | 2,070 |
| 90 | 18,800 | 21,800 | 22,600 | 23,850 | 24,100 | 24,700 | 26,250 | 11,270 | 12,550 | 13,150 | 1,300 | 1,510 | 1,540 | 1,870 | 1,900 |
| 95 | 17,830 | 20,600 | 21,250 | 22,300 | 22,550 | 23,100 | 24,350 | 10,470 | 11,570 | 11,950 | 1,200 | 1,400 | 1,420 | 1,720 | 1,740 |
| 100 | 16,900 | 19,400 | 20,000 | 20,800 | 21,100 | 21,500 | 22,600 | 9,700 | 10,600 | 10,900 | 1,110 | 1,300 | 1,300 | 1,580 | 1,610 |
| 105 | 16,010 | 18,300 | 18,800 | 19,500 | 19,800 | 20,100 | 21,000 | 9,060 | 9,750 | 10,000 | 1,020 | 1,200 | 1,200 | 1,470 | 1,480 |
| 110 | 15,160 | 17,200 | 17,700 | 18,200 | 18,500 | 18,730 | 19,500 | 8,400 | 8,940 | 9,200 | 950 | 1,120 | 1,110 | 1,360 | 1,370 |
| 115 | 14,350 | 16,200 | 16,650 | 17,100 | 17,300 | 17,530 | 18,150 | 7,860 | 8,260 | 8,500 | 880 | 1,040 | 1,020 | 1,260 | 1,270 |
| 120 | 13,580 | 15,300 | 15,680 | 16,000 | 16,200 | 16,400 | 16,900 | 7,320 | 7,650 | 7,900 | 820 | 970 | 950 | 1,170 | 1,180 |
| 125 | 12,850 | 14,400 | 14,750 | 15,030 | 15,200 | 15,400 | 15,850 | 6,850 | 7,100 | 7,350 | 760 | 910 | 885 | 1,090 | 1,100 |
| 130 | 12,160 | 13,600 | 13,920 | 14,150 | 14,260 | 14,460 | 14,830 | 6,400 | 6,620 | 6,860 | 710 | 850 | 825 | 1,020 | 1,020 |
| 135 | 11,510 | 12,800 | 13,120 | 13,330 | 13,400 | 13,600 | 13,930 | 6,000 | 6,190 | 6,400 | 665 | 800 | 775 | 950 | 950 |
| 140 | 10,900 | 12,100 | 12,350 | 12,550 | 12,620 | 12,800 | 13,100 | 5,630 | 5,810 | 6,000 | 625 | 750 | 725 | 890 | 890 |
| 145 | 10,320 | 11,450 | 11,700 | 11,830 | 11,900 | 12,050 | 12,350 | 5,300 | 5,470 | 5,600 | 585 | 710 | 680 | 835 | 835 |
| 150 | 9,800 | 10,800 | 11,020 | 11,150 | 11,220 | 11,350 | 11,630 | 5,000 | 5,170 | 5,260 | 550 | 670 | 640 | 785 | 785 |
| 160 | 8,850 | 9,700 | 9,850 | 9,970 | 10,040 | 10,120 | 10,350 | 4,450 | 4,600 | 4,650 | 490 | 590 | 570 | 690 | 690 |
| 170 | 8,000 | 8,750 | 8,850 | 8,950 | 9,020 | 9,100 | 9,300 | 3,980 | 4,100 | 4,130 | 440 | 530 | 510 | 620 | 620 |
| 180 | 7,320 | 7,900 | 8,000 | 8,100 | 8,150 | 8,200 | 8,300 | 3,590 | 3,680 | 3,700 | 390 | 470 | 450 | 560 | 560 |
| 190 | 6,690 | 7,200 | 7,260 | 7,320 | 7,350 | 7,400 | 7,500 | 3,250 | 3,300 | 3,300 | 355 | 420 | 410 | 510 | 510 |
| 200 | 6,110 | 6,550 | 6,610 | 6,670 | 6,700 | 6,750 | 6,800 | 2,950 | 3,000 | 3,000 | 320 | 380 | 370 | 460 | 460 |
| 210 | 5,570 | 6,000 | 6,050 | 6,100 | 6,100 | 6,150 | 6,200 | 2,700 | 2,730 | 2,730 | 290 | 350 | 340 | 415 | 415 |
| 220 | 5,100 | 5,500 | 5,550 | 5,600 | 5,600 | 5,650 | 5,700 | 2,480 | 2,500 | 2,500 | 265 | 320 | 310 | 380 | 380 |
| 230 | 4,700 | 5,100 | 5,130 | 5,150 | 5,150 | 5,200 | 5,230 | 2,280 | 2,280 | 2,280 | 240 | 290 | 280 | 345 | 345 |
| 240 | 4,330 | 4,700 | 4,720 | 4,750 | 4,750 | 4,800 | 4,800 | 2,100 | 2,100 | 2,100 | 225 | 270 | 260 | 320 | 320 |
| 250 | 4,030 | 4,350 | 4,370 | 4,400 | 4,400 | 4,450 | 4,450 | 1,930 | 1,930 | 1,930 | 210 | 255 | 245 | 300 | 300 |
| 260 | 3,750 | 4,060 | 4,070 | 4,100 | 4,100 | 4,130 | 4,130 | 1,790 | 1,790 | 1,790 | ..... | ..... | ..... | ..... | ..... |
| 270 | 3,500 | 3,800 | 3,800 | 3,820 | 3,820 | 3,850 | 3,850 | 1,660 | 1,660 | 1,660 | ..... | ..... | ..... | ..... | ..... |
| 280 | 3,260 | 3,500 | 3,500 | 3,520 | 3,520 | 3,550 | 3,550 | 1,550 | 1,550 | 1,550 | ..... | ..... | ..... | ..... | ..... |
| 290 | 3,050 | 3,300 | 3,300 | 3,310 | 3,310 | 3,330 | 3,330 | 1,460 | 1,460 | 1,460 | ..... | ..... | ..... | ..... | ..... |
| 300 | 2,860 | 3,100 | 3,100 | 3,100 | 3,100 | 3,100 | 3,100 | 1,380 | 1,380 | 1,380 | ..... | ..... | ..... | ..... | ..... |

mentioned, that the safe loads given by the Pencoyd tables are obtained from the ultimate loads by means of a factor of safety which increases with the value of $\frac{l}{r}$.

## THE MARINE STEAM ENGINE INDICATOR—XVII.*

BY LIEUT. CHARLES S. ROOT, U. S. R. C. S.

### THE EXPANSION LINE.

The law of the compressibility of gases was first published by Boyle in 1662, and by Mariotte in 1679, the latter having made experiments entirely independent of Boyle. In Great Britain this law is commonly spoken of as "Boyle's Law," and on the Continent as the "Law of Mariotte." It is as follows:

*The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure which it bears.*

Until quite recent times, Boyle's law was supposed to be true for all gases at all pressures. Depretz was the first to obtain results incompatible with the law. The experiments of Regnault in 1847 were distinguished by the extreme nicety with which they were made and finally established the fact that the law is not exact. Regnault's conclusions were, in part, as follows: "That no gas rigorously obeys Boyle's law; the divergence being small for low pressures but increasing with the pressure." The divergence from the law is greater with easily liquefiable gases, such as carbonic acid and ammonia, than for (the gases called in Regnault's time) permanent gases, such as oxygen and nitrogen. Thus to reduce air to 1/20 of its original volume, he found that a pressure of 19.72 atmospheres (19.72 × 14.7 pounds) was required, instead of 20, hydrogen required 20.27, while carbonic acid required only 16.71 atmospheres.

Turning now to expansion in the steam cylinder: It is safe to say that all engines (excepting direct acting steam pumps and certain classes of auxiliaries) use steam expansively, that is, the supply of steam is cut off before the piston reaches the end of its stroke. James Watt was the first to apply the cut-off and used this as one of several methods to increase the economy of his engines. He assumed that the law of Boyle was true in the case of steam and explained the superior economy of his engines (so much as was due to using the cut-off) by the aid of what he termed a "diagram of work done during expansion." His method of reasoning was somewhat as follows: *Work* (in the case of an engine) may be defined as *pressure multiplied by the distance through which it acts.* Suppose we have a piston of 100 square inches area, the piston working through a stroke of 1 foot. If this piston is acted upon by a pressure of 1 pound per square inch, the load on the piston is 100 pounds and the work 100 pounds times 1 foot or 100 *foot-pounds* per stroke. To get this 100 foot-pounds it is necessary that the cylinder be completely

* Copyright, 1911, by Chas. S. Root.

filled with steam from the boiler at each stroke. If the steam be cut off at half stroke the average or mean pressure per stroke will be about .85 pound per square inch with 1 pound initial pressure; the total load on the piston will be .85 × 100 pounds and the work per stroke .85 × 100 × 1 or 85 foot-pounds. Without cut-off, a whole cylinder full of steam gives 100 foot-pounds, while with cut-off at half stroke a whole cylinder full of steam will drive the piston through two strokes and produce 85 × 2 or 170 foot-pounds, a result showing 70 percent more work for the same quantity of steam than was produced without cut-off. This gain, however, is purely theoretical and, for various reasons, which will be discussed later, is considerably more than is actually realized.

quently hear it referred to as a $p\ v$ curve. There are many simple methods in use for laying out this curve, but in the writer's opinion the best way is to locate the points by computation as follows.

Get the value of $p\ v$ first. In the curve of Fig. 101, $p = 100$ and $v = 1$. Therefore $p\ v = 100$. Next compute the value of $v$ at any desired number of places above the line $OA$ (which is drawn at 45 degrees with $OX$ and $OY$) thus: $100 \div 90 = 1.11$, $100 \div 80 = 1.25$ and so on to $100 \div 35 = 2.85$. Locate the points on the co-ordinate lines. Now, beginning on the other side of $OA$, solve for $p$ instead of $v$ $100 \div 4 = 25$, $100 \div 5 = 20$, and so on until the final pressure $100 \div 10$ is reached. As a check, the point where the

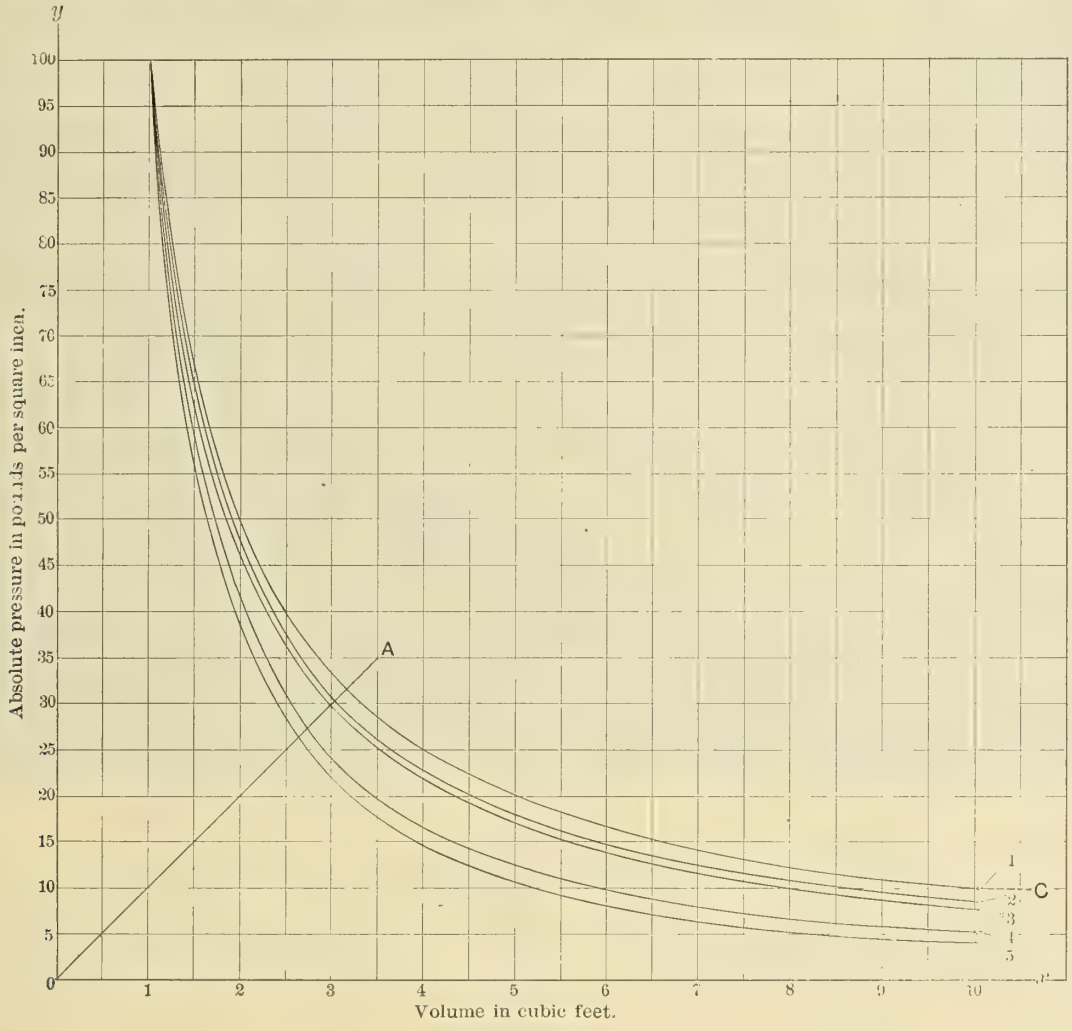



FIG. 101.

Referring to Fig. 101, the upper curve (or curve No. 1) is a rectangular or common *hyperbola,* rectangular, because its co-ordinates form an angle of 90 degrees with each other. Its equation[1] is $p\ v = constant$, where $p$ = pressure and $v$ = volume. This curve, as drawn in the figure, represents graphically the expansion of one cubic foot of a perfect gas at 100 pounds absolute pressure to 10 cubic feet, all at *constant temperature,* in accordance with Boyle's law. Its height above the zero line of pressure, or base, shows the gas pressure at the corresponding volume. In mathematics, this curve is known as a hyperbola, as stated above, and in consequence expansion which takes place in accordance with Boyle's law is often called hyperbolic expansion. The curve is also known as an *isothermal* or curve of equal temperatures and we frequently hear it referred to as a $p\ v$ curve. There are many simple methods in use for laying out this curve, but in the writer's opinion the best way is to locate the points by computation as follows.

Get the value of $p\ v$ first. In the curve of Fig. 101, $p = 100$ and $v = 1$. Therefore $p\ v = 100$. Next compute the value of $v$ at any desired number of places above the line $OA$ (which is drawn at 45 degrees with $OX$ and $OY$) thus: $100 \div 90 = 1.11$, $100 \div 80 = 1.25$ and so on to $100 \div 35 = 2.85$. Locate the points on the co-ordinate lines. Now, beginning on the other side of $OA$, solve for $p$ instead of $v$ $100 \div 4 = 25$, $100 \div 5 = 20$, and so on until the final pressure $100 \div 10$ is reached. As a check, the point where the curve crosses $OA$ may be computed from the following formula:

Let $T$ = the distance $XC$,
$L$ = " " " from $O$ to 10 on the $X$ axis,
$T \times L = D$ (in inches)
and let $F$ = the distance in inches from $O$ at which the hyperbola crosses the diagonal $OA$.

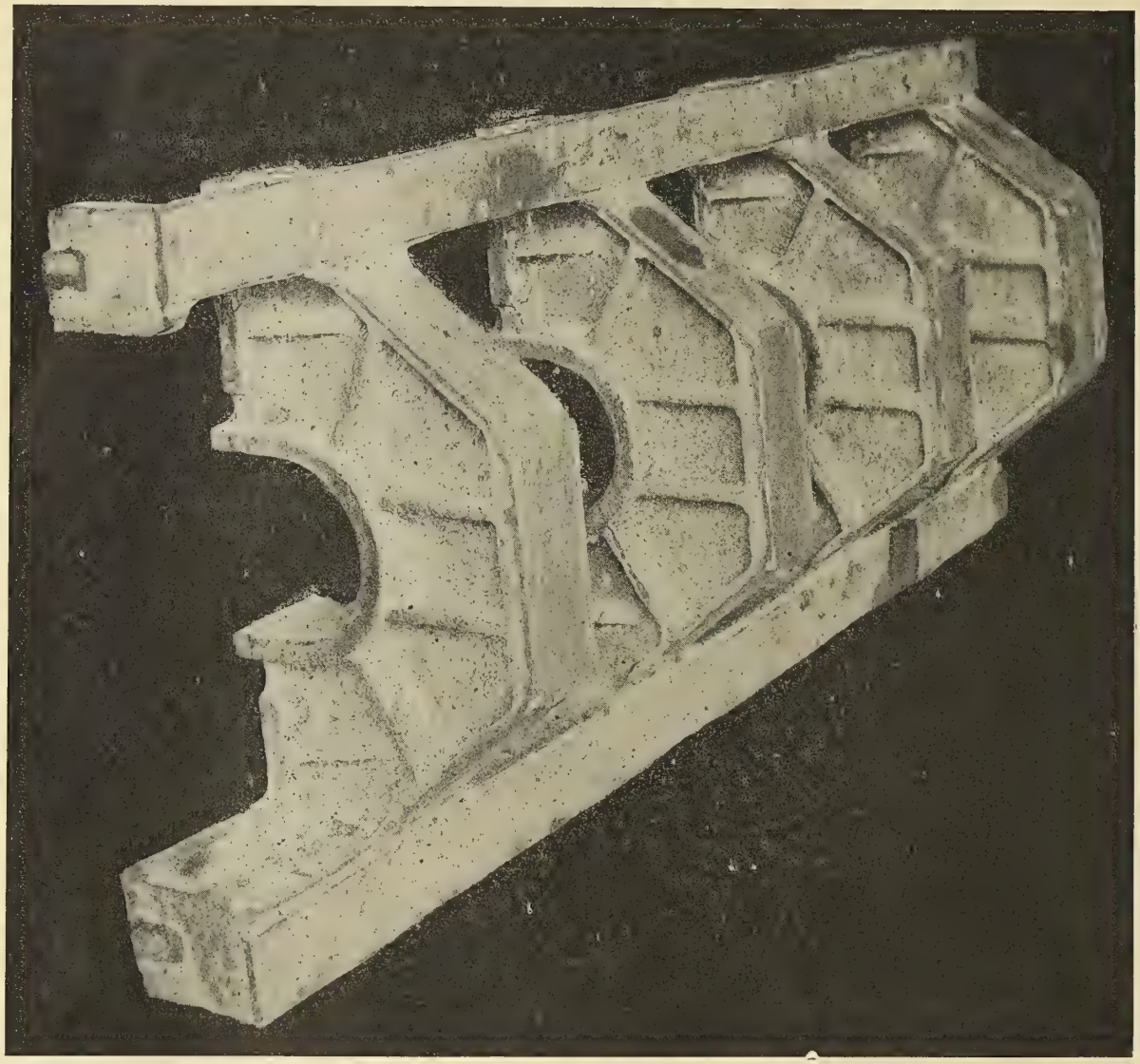
Then will $F = \sqrt{2D}$.

In Fig. 101, if we assume each of the lines forming the squares to be one inch apart and substitute these dimensions in the formula we shall have $TL = D$ or $20 \times 2 = D$ and by substituting this value of $D$ in $F = \sqrt{2D}$ we have

$$F = \sqrt{80}$$

or $F = 8.9$ inches.

[1] See September, 1910, issue, page 378.



VANADIUM CAST STEEL ENGINE BED PLATE FOR MARINE TORPEDO BOAT

## Vanadium Steel is Efficiency Steel

For smaller repair bills, for less weight per unit of strength, for greater safety, for unexcelled vitality, for the severest services in the highest classes of mechanical construction,

## Vanadium Steel is the Ideal Steel

The reasons why and the mode of applying Ferro-Vanadium for the solution of the hardest problems of Engineering as far as steel is concerned, are fully presented in our booklet.

If you make steel use "Amervan" Ferro-Vanadium. If you buy Vanadium Steel, insist on a product containing "Amervan" Ferro-Vanadium Other Vanadium alloys contain impurities that destroy the benefits of the Vanadium. As developers of the Vanadium Industry in America we have processes of manufacture that insure the highest qualities in our alloys.

# American Vanadium Company

Miners of Vanadium Ores

Largest producers of Vanadium Alloys in the world

318 Frick Building, Pittsburgh, Penna.

# MARINE ENGINEERS

## SHOULD SPECIFY THESE METALS—

### VICTOR VANADIUM
**BRONZE CASTINGS**

This Bronze composition is particularly adapted for Modern Marine Service, and is rendered tough, strong and uniform by the incorporation of Vanadium, which is considered the greatest of all scavenger alloys, imparting to the metal greater wearing qualities. This bronze is ten per cent lighter in actual weight than any other bronze casting of the same pattern.

These castings can be forged.

The structure is close and clean, capable of withstanding high pressure for valve service.

A cylinder 9-16 of an inch thick, three inches in diameter and fifteen inches long has been subjected to a pressure of nine thousand pounds.

**TENSILE STRENGTH on 1" Section:**
**56000 to 65000 lbs. per square inch.**

**ELASTIC LIMIT:**
**22000 to 34000 lbs. per square inch.**

This metal is used in submarine vessels in Japan, Austria, Russia and every vessel of this type in the United States.

### VICTOR VANADIUM
**NON-CORROSIVE SILVER METAL**

This Metal is non-corrosive and is particularly useful for sea-going service.

It finishes to a silver color and takes a high polish whose lustre can be maintained quite readily by simply rubbing, adding greatly to its usefulness and effect as ornamental hardware for marine use

It is an ideal metal for propellers, for it withstands salt water and all vegetable and mineral acids, nitric acid excepted. It is of great strength and toughness and should be used for valves and couplings for fire apparatus on account of its non-corrosive qualities, in place of nickeled castings, as nickel finally peels off, and this metal not being plated, cannot peel.

**TENSILE STRENGTH:**
**66000 lbs. per square inch.**

**ELASTIC LIMIT:**
**36000 lbs. per square inch.**

This metal will be found indispensable to marine service when once used.

## WRITE FOR CATALOG

# VANADIUM METALS COMPANY

**FRICK BUILDING**

## PITTSBURGH, PENNA.

# PRACTICAL EXPERIENCES OF MARINE ENGINEERS.

## Incidents Relating to the Design, Care and Handling of Marine Engines, Boilers and Auxiliaries, Breakdowns at Sea and Repairs.

### Explosion of a Valve Receiver.

Have you heard of an explosion happening in an engine while cool?

This was what occurred in the steamship *Cantabria* off the coast of the Philippine Islands, where I was third engineer. This steamer, formerly named *Formosa*, of the Hongkong-Manila Line, was fitted with a triple-expansion engine of approximately 700 indicated horsepower. The cylinders and valve chests were arranged in the following order, beginning from the foreside: Intermediate-pressure valve receiver, high-pressure piston valve, high-pressure cylinder and low-pressure cylinder; the low-pressure valve and receiver were placed at the post side of its corresponding cylinder. This receiver was fitted with two covers, one vertically and the other horizontally placed. (See Figs. 1 and 2.) One steam pipe connected the intermediate-pressure and low-pressure receivers. As is seen in Fig. 1 there were two stay-rods of 2-inches diameter, with straps fastened to the cylinder walls to keep them closed.

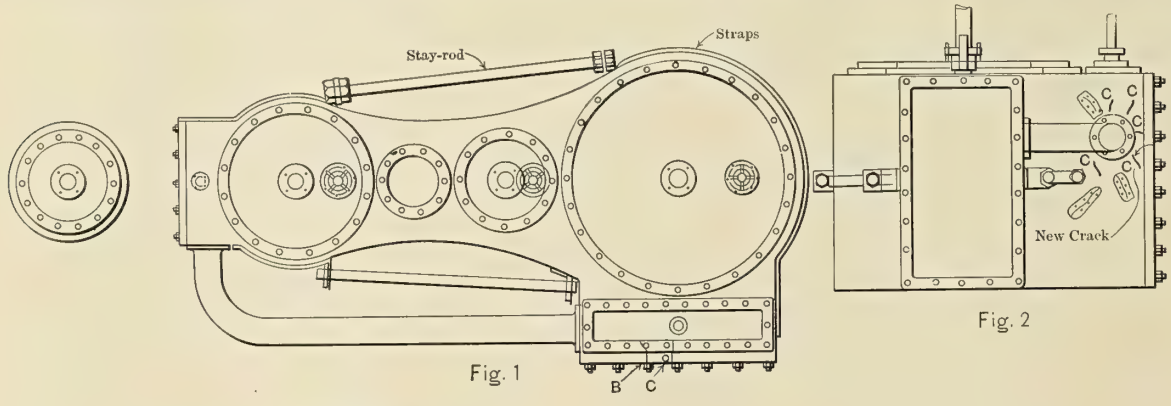



Fig. 1 Fig. 2

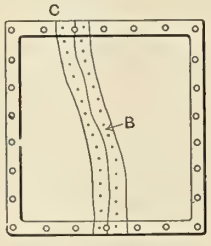



Fig. 3

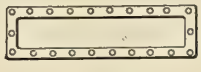


Fig. 4

On the morning of Good Friday of 1904 we arrived at the port of Legazpi, at the foot of the volcano Mayon. After cleaning out the grease we allowed the engine to become cool. The chief engineer, on the next day, about 10 o'clock A. M., gave us orders to get the engine ready for examining the leads of the three steam valves. After connecting the turning gear we turned our attention to the high-pressure piston valve, removing the cover head, scraped the cake oil and turned the engine in an effort to find the high dead point of the high-pressure crank. After examining the leads of both go-ahead and astern we turned the engine and placed the crank at its lower dead point. The chief examined the leads, and finding both bottom and top O. K., ordered us to cover the valve and take off the cover of the intermediate-pressure. We did so, and when we got it opened and placed the intermediate-pressure crank at its high dead point the chief came down, grasping with his right hand a bunker lamp and went to examine the valve leads, reflecting the light into the valve chest on the same side where the connecting pipe was fixed. At the precise moment that he got the light inside we heard a tremendous noise that produced a great commotion in the whole ship, as if a charge of dynamite had exploded. A large quantity of grease and black smoke escaped from the open receiver, tarnishing the bulkhead, which was about 28 inches away, and burning part of the chief engineer's face and right eye.

After a brief moment of very natural fright we went to the assistance of the chief. The captain and other officers who advanced to the skylight to inquire about the cause of the explosion called out attention to a light white smoke noticeable between the low-pressure receiver and its vertical cover. I went there, and to my great surprise readily saw that the cover was broken in two pieces (Fig. 3). I also noted two 1-inch studs with their respective nuts laying on the floor; studs which had been rooted out from their location on the broken cover (Fig. 3 *c*.).

Then we aided the chief in going to his bunk, where he was assisted by the deck officers. The second engineer and myself turned back to the engine room, where we proceeded to make a more complete investigation of the thing which we looked upon as phenomenal. We removed the broken cover, as well as part of the cylinder lining, and at once saw several cracks in the fore part of the receiver (Fig. 2) and two more on the stud-holes of the upper edge, where were fixed the rooted-out studs of the vertical cover, one of the cracks extending to the upper corner, reaching the port side edge of the upper cover.

We also noticed that there were several cracks existing and also, as could be plainly seen, patches. So we concluded that the recent explosion had a precedent in the same engine, which idea was reinforced on our part by the two stay-rods and straps that were fixed for strengthening the upper part of the engine.

As we had to continue the trip, and, moreover, as there was no machine shop in the town, we set about making the necessary temporary repairs with the tools and materials that we had at our disposal on board. First we drilled a row of 7/16-inch holes along the edge of each broken piece of the cover, having a distance of about 5/8 inch and about 2½ inches apart from center to center. The holes were tapped with ½-inch thread. Then, with one 3/8-inch iron plate, the only plate that we had on board, we made a patch, giving it a width of about 6 inches to cover the sinuous line of fracture, making the rivets with one ½-inch iron rod, threaded at one end to screw down the cover, and subsequently fixing the patch on the inside face of the cover by means of good riveting.

As we had only one drill (ratchet) we were compelled to finish one part of the repair before attacking another. So after having concluded the cover we then proceeded to remedy as quickly and as well as possible the larger cracks recently produced on the receiver. This we fixed by several bolts along the cracks to hold them within their limits, until our arrival at Manila, where better means for good and permanent repairs could be accomplished. We completed the repairs and were able to set steam 24 hours after the explosion. The trip was continued with some steam leakage through the cracks.

As may be supposed, from the moment of the explosion we began to inquire (among ourselves) how such breakdown could have happened and what was its prime cause. The engine was cool, as has been said, and several complete turns had been given it, and furthermore a light, the same bunker lamp used by the chief (and which acted as a fuse) was introduced in the high-pressure cylinder valve without disturbance of any kind. The supervising engineers of the ship and of the insurance company, who boarded the ship immediately on our arrival at Manila, after investigating the conditions, gave as their opinion that the cause of the disaster was due to decomposed gases, caused probably in part by the cylinder oil and in part by the petroleum used on the boiler by former engineers.

That this oil and petroleum by accumulation in the pipe had converted itself in a specy like a cannon.

Can any opinion be given different from the one expressed?

When we arrived at Manila and after the supervising engineers authorized the repairs, we began the fixing of a new cover and patching the cracks of the receiver. And in order to augment solidity to the weakened receiver (and it could not be renewed, for the cylinder and receiver were of a solid piece and the machine shop had no materials to cast a new one), an iron frame ½ inch thick, of the shape of the upper cover, was fitted, renewing, of course, all studs by larger ones. (Fig. 4.)

The ship was unfortunate and subsequently was wrecked by a typhoon in September, 1906, when every soul perished in her.

Philippine Islands. AUGUSTO SUZARA.

## A Broken Thrust Shaft.

The S. S. "B——," while on a voyage from India to England, with a full cargo of tea, broke her thrust shaft, which the engineers of the ship managed to repair temporarily. The repair was made in this way: We cut a slot through the broken ends and inserted one of the crank shaft keeps into the slot, keeping the shaft ends and keeps in position with wrought iron bands. After we had traveled several hundred miles, however, the repairs gave out, and we were left helpless; at this point of the voyage we were out a long way from Bombay, so our captain decided to make for this point under sail; after five days, we reached this port safely under the aid of our scanty sails alone, which, I might say, were made from canvas hatch covers. We then set about looking for another shaft, and after considerable hunting, we got one which turned out to be something near what we wanted. We had it cut to suit the length, and turned out to suit the thrust block rings; it was also fitted with two cast iron couplings, 9 inches thick at either end. The couplings were secured to the shaft by longitudinal keys. Having had these repairs completed, we proceeded up the Red Sea and through the Canal without anything unusual happening, except of course that we had to keep a strict watch on the shafting. After leaving Port Said, however, for a Mediterranean port, it was observed from the working of the thrust block and stern tube that the whole of the shafting and its connection seemed to be strained and out of true alinement, so much so that the inner end of the stern tube worked round with each revolution no less than half an inch, causing a constant and serious leakage of water into the ship. However, by keeping the pumps at work all the time, we managed to get to port safely, and there we underwent an examination and had an entirely new thrust shaft, bearings, and tube fitted.

F. J. S. N.

## Practical Operation of Parsons Turbines.

A venerable Scotchman, the senior chief engineer of a certain line of 'cross Channel steamers, was transferred to the latest addition to the fleet, a high-speed vessel, driven by Parsons' turbines. After the new job had been running a few weeks the superintendent of the line, feeling that the old man would find the turbines a vast change from the slow-speed paddle engines to which he had been accustomed, asked him if he found any difficulty with the new system. "No," said he, "I do not. "I'll tell ye (very confidentially), it's just like this with the turbines—you open the regulator and trust in God."

So far as it went, his observation was entirely correct, but there are other things required in the successful management of a turbine installation in addition to faith, and the object of these notes is to point out what some of these other things are.

Coming from the reciprocating engine, with its multiplicity of working parts to lubricate and adjust, the engineer will naturally consider the operation of the turbine, with its absence of visible working parts and automatic lubrication, to be a much simpler business. So it is, but, all the same, the turbine calls for intelligent handling and in some respects is a much more delicate piece of machinery than a reciprocating engine.

In a Parsons turbine there are hundreds of revolving blades with their tips running within from 25/1000 to 1/10 inch of the stationary cylinder, and hundreds of stationary blades with the revolving portion running at similar clearances from them. In addition, the fore-and-aft clearance between the revolving dummy and the stationary dummy rings is usually about 20/1000 inch. Should any of these clearances disappear the result would be disastrous.

On the other hand, it must not be imagined from this that breakdowns are frequent—far from it. In fact, it may be said that when properly designed and constructed and intelligently handled it would be difficult to improve upon the Parsons turbine, as far as freedom from breakdown is concerned. A breakdown with a reciprocating engine is seldom of such a nature that it cannot be repaired at sea. However, with the turbine, when breakdown does occur, it is usually in connection with the blading or dummy rings, and such an accident is often in the nature of a complete smash which is beyond the

power of the operating engineers to repair. It behooves the engineer in charge, therefore, to keep the idea of these fine clearances (which are entirely out of his sight and control) constantly before him, and to err always on the side of caution and take no risks.

Now the operation of a turbine installation may be divided into three sections:

1. Heating up the turbines and getting under way.
2. Operation when under way.
3. Overhauling.

Considering Section 1 it is evident that the turbine cylinders, although perfectly cylindrical and symmetrical when cold, will distort to some extent when hot, consequently the blade-tip clearances will be reduced. The clearances are usually made ample to allow for this. On the other hand, if the turbine is quickly or carelessly warmed up so that unequal expansion results, the distortion of the cylinder becomes very much greater and a grave risk is run of stripping the blading when the turbine is started up. Thus, the greatest care is necessary to make the heating-up process as long and gradual as possible. With even the smallest installation it is advisable to take not less than six hours to the operation, and about twelve hours with large turbines.

The procedure in warming up may be somewhat as follows, although, of course, it may be modified to suit individual circumstances:

Usually an auxiliary boiler is set away previously, so as to have auxiliary steam available. If water-tube boilers are installed a single boiler may be selected for warming up, but if cylindrical boilers are fitted they will all have to be lighted up as soon as possible.

When fires are set away and all air cleared off and steam showing, crack open the boiler stop-valve. Open the bulkhead stop-valves and regulator valves, and any drain cocks that may be fitted to the main steam range. The self-closing valves in the receiver pipes between the turbines should be opened wide, so as to allow the vapor to pass through the turbines to the condenser. Open full all the turbine drain valves and also the valve (usually fitted at the air pump) which drains the turbines to the bilge.

The circulating pumps should be started up and kept going slowly during the process of heating up. After the air has been driven off and steam is blowing at the drain to bilge, close this valve and start the air pumps, keeping them just on the move.

The pressure on the turbine should not be allowed to exceed about 12 pounds per square inch for the first few hours. It is the usual practice to put in the turning gear and give the rotors a turn, say, every half hour, to insure that they expand equally, but if plenty of time is given to heating up this may be dispensed with. After six to eight hours, the turning gear may be taken out. During this time the available steam pressure will have risen considerably, and it will have been necessary to almost close down the main regulating valve.

When full pressure is reached, the turbines being now hot, very little is necessary to set them moving. The regulator may be opened at intervals for a few minutes at a time to keep the turbines thoroughly warmed up, without actually moving them, until nearer the time for getting under way. Before reporting ready, the lubricating oil pump should be started and kept going slowly, and the oil test cocks and sight doors on the bearing looked to, to see that the oil is moving properly. Steam may now be put on the outer pockets of the turbine glands, the valves being adjusted to give a pressure of about 1 pound per square inch. The various drain cocks about the steam system should also be tried, to make sure that all water is cleared out.

Having ascertained that the propellers are all clear, sufficient steam may be given to each turbine in succession (including the astern turbine) to cause it to move a few revolutions, and steam should be left on the turbines that will be used for maneuvering. The air, circulating and forced lubrication pumps may be speeded up in readiness for starting and everything being satisfactory "All ready" may be reported.

Just before starting, the drain valves on the turbines which are actually to be used should be closed. If the usual three-shaft arrangement of turbines is fitted, with the high-pressure on the center shaft and the low-pressure and astern turbines on the wing shafts, the wing shafts only will be required in working out of harbor. The high-pressure turbine will be allowed to revolve idly in a vacuum, its drain valve being left open, which is practically equivalent to connecting it to the condenser. This applies to any turbine which is allowed to revolve without doing work, no matter what arrangement of turbines is installed. Thus, when cruising turbines are fitted, their drain valves are kept open when these turbines are not developing power. The drain valves of the turbines in which work is being done are kept closed when under way, the whole system being drained from the exhaust end of the low-pressure turbine through a non-return valve of the "King-horn" type and a water seal.

When starting the turbines it is of great importance to open the regulating or maneuvering valves gradually. If this is not done a sudden rush of steam will result which is very apt to start priming and cause damage to the blading. The turbine has the reputation of being much more liable to cause priming than the reciprocating engine, and the writer's experience bears this out.

The engineer should remember that the turbine can take up as much steam at starting as when it has run up to speed, whereas the reciprocating engine's appetite for steam only increases with the speed at which it runs. Gradual opening out is especially necessary when operating the astern turbines, as with them only comparatively few rows of blades separate the boilers from the condenser. This caution is essential, and even when gradually opened out, full steam should not be given to the astern turbines unless full boiler power is available.

Several cases of severe priming with turbine jobs have come within the writer's experience which were due to the boiler stop valves being opened too widely. The stop valves on the boilers nearest the turbines should only be opened slightly if priming is to be avoided. This applies more especially with ordinary cylindrical boilers.

Turning now to Section 2, operation when under way, once in open waters the turbines must be changed over from maneuvering to running conditions. Thus, if the usual three-shaft arrangement is fitted, the high-pressure turbine drain valves should be closed, the maneuvering steam valves (ahead or astern) shut, and main steam admitted to the high-pressure turbine. If cruising turbines are installed, the proportion of full power to be developed will decide which (if any) are to be used in conjunction with the main turbines, or whether they are to revolve idly with their drain valves open.

If the vacuum augmentor system is adopted, circulating water may be put on the augmentor condenser and steam admitted to the augmentor jet. The air and circulating pumps should be operated to give the highest vacuum attainable. The vaccum is a most important point in a turbine installation and should receive the fullest attention. With a turbine (unlike a reciprocating engine) the vacuum cannot be too high, every increase showing a marked decrease in the steam consumption for the same power. The engineer in charge cannot give too much attention to this part of the system, and additional care with the jointing that is subject to the vacuum will be well repaid. Only the turbines should exhaust to the main

condensers if a high vacuum is to be obtained. If the closed exhaust arrangement is fitted it should certainly be used. With this arrangement the exhaust from the auxiliary engines is connected to any one of several points on the main turbines—the connection to be selected depending on the degree of power being developed by the turbines. This decides at which connection a suitable pressure will be found. Thus, at low powers the auxiliary engine exhausts may be connected to the beginning of the second expansion of the high-pressure turbine (if cruising turbines are fitted), while at full power the suitable point would probably be the second expansion of the low-pressure turbine. Again, at intermediate-powers the exhausts may be put into the receiver pipes between the high-pressure and low-pressure turbines. By adopting this system not only is additional power obtained by utilizing the auxiliary engine exhausts, but the improved vacuum results in a gain in economy.

It will be readily understood that any steam connection which enters the turbines in way of the blading requires careful handling, as any sudden rise in temperature is very liable to cause local distortion, with the risk of blade stripping. Thus, when operating such of the closed exhaust connections which enter the turbines in way of the blading, the controlling valve should be first well drained before being gradually opened.

The by-pass valve which admits full-pressure steam to the end of the first expansion of the high-pressure turbine calls for cautious operation, and several accidents have been caused by careless handling of this fitting.

The steam to the turbine glands should be adjusted to allow a slight escape of steam, just sufficient to insure that no air can leak in. A pressure of about 4 to 5 pounds per square inch in the outer gland pocket will usually suffice. The high-pressure and cruising turbines are usually fitted with glands having two and sometimes three steam pockets. The inner of these have valve-controlled connections led to some point of lower-pressure to which the steam which escapes past the first rows of gland fins is "leaked-off."

Thus the inner pockets of a cruising turbine gland would be connected to some point down the expansions of the high-pressure turbine, while the high-pressure turbine inner gland pocket may be connected to the second expansions of the low-pressure turbines. The outer pockets of the high-pressure and cruising turbine glands have generally a steam connection to obviate air leaks, and in addition a connection for leaking-off the escaped steam to the condenser, should the inner pocket leak-off be unable by itself to relieve the pressure. The engineer should endeavor to keep a suitable pressure in the outer pocket without having to use the connection to the condenser. If the high-pressure or a cruising turbine be revolving idly in a vacuum, the inner pocket leak-off must be closed, and the steam on the outer pocket will keep out the air.

The low-pressure turbine glands are always subject to a vacuum, so that a single pocket fitted with a steam connection only is all that is required. The actual operation of the gland steam is probably simpler than the explanation, but the arrangements adopted vary to such an extent that it is only possible to treat the subject generally. In merchant vessels the connections are usually very simple, the more elaborate arrangements being fitted to naval vessels in which cruising turbines are adopted.

A vital point in a turbine system is the lubrication. Forced lubrication is generally fitted, the oil being pumped through a cooler (similar to a surface condenser) on its way to the bearings. The circulating water for this cooler is sometimes taken from the discharge side of the main circulating pumps, or a special pump is fitted, which should, of course, be started up with the forced lubrication pump. On the turbine bearing caps are fitted sight doors, a pressure gage, and a test cock, which call for frequent observation. The oil after leaving the bearings flows by gravity to the oil-drain tank, from which the pumps draw, the oil passing through a strainer on its way to the pumps. The pumps are usually in duplicate, one acting as a stand-by, and it is a great advantage to have two oil-drain tanks, as one can be used to allow the oil to settle and cool, while the other is in service. The oil coolers are not always very effective and they are very liable to trap air. The writer has found the fitting of an air cock to be of considerable advantage in some cases.

It is usual to carry an oil pressure of about 1 pound per square inch at the bearings, as a high-pressure is very liable to cause leakage, but every job should be treated on its own merits. The temperature of the bearings is generally higher than is usual with reciprocating engines. Trouble with hot bearings is not common with turbines, but when a bearing does heat up it heats up quickly. The oil supply must never be allowed to cease even for the shortest period. A case occurred within the writer's experience in which the stoppage of the oil pumps was unnoticed for a few moments, and he is not likely to forget the result. As an additional precaution reserve oil tanks arranged as high up as possible are sometimes fitted, and these tanks can in an emergency supply oil to the bearings by gravity. Thermometer connections are now commonly fitted to indicate the temperature of the oil leaving the bearings, and the temperature so indicated should be recorded.

When under way the turbine requires little attention in comparison with the reciprocating engine. Every effort should be made to keep the vacuum high while the oil pressure and bearing temperatures should be carefully observed. In addition, a lookout should be kept for any variation in the steam pressures at the various turbines and gland pockets. The dummy clearance should be tried at the "finger piece" every watch, while a more accurate measurement by means of the dummy clearance micrometer may be made every day. However, the detailed explanation of the method of carrying out these operations would require a special article in itself.

The engineer should, of course, pay attention to any variation in the usual noise of the turbines, as the presence of loose binding strips, etc., or foreign matter in the blading may sometimes be detected in this way. The presence of water in the turbine also modifies the sound.

On the other hand, the writer remembers a turbine which at one particular speed made a noise resembling a brass band, although the blading was quite sound. Again, on the trial trip of a certain 'cross Channel steamer, at which the writer was present, when on the measured mile a tremendous, shrieking noise was set up. As this was in the early days of the turbine trouble with the blading was feared, and the engines were immediately stopped.

After some investigation, the cause of the trouble was eventually traced to the main regulator valve. This valve was fitted with flexible disc seats and at one particular pressure these flexible discs vibrated, causing the shrill noise.

### OVERHAULING.

The overhauling of a set of turbines is generally a big job. A lot of pipes and fittings have to be dismantled and stowed away, and often a considerable amount of gear has to be erected before the actual work of opening up the turbines can be commenced. At least a week would be required for the overhaul of even the smallest job, while three or even four weeks would not be excessive with some of the larger installations. Thus the opening up of a set of turbine machinery is carried out at much longer intervals than is usual with reciprocating engines.

On the other hand, there is no doubt that the engineer in charge should see the inside of his turbines and ascertain the conditions of the blading, dummy rings, etc., as often as

possible. If it is impossible to get the time necessary for a complete overhaul, only one turbine may be opened out whenever an opportunity occurs. The various steam strainers should be examined at intervals, the cages being withdrawn and cleaned. The bridge gage which measures the wear-down (if any) of the turbine rotors should be tried at the end of every trip and the results carefully recorded.

Before proceeding to open up any of the turbines, the engineer in charge should carefully consider what operations are to be carried out, exactly how they are to be carried out, and in what order, if confusion is to be avoided. The exact arrangement of the turbine lifting gear to be adopted depends on several circumstances, and naturally varies with the arrangement of turbines and the space available. The builders usually supply a drawing with the ships which indicates the methods to be followed, and a careful study of this will usually repay the engineer.

One point should be noted. When the astern turbine is incorporated with the low-pressure (as is usual), it must be remembered that the astern cylinder joint (which is inside), must be broken before the low-pressure cylinder cover can be lifted. The writer remembers a case where this point was forgotten, with the result that one of the lifting lugs (cast with the cylinder) was broken off.

After a cylinder cover is lifted on the four guide pillars it is usually traversed by the lifting blocks in either a fore and aft or athwartship direction and deposited. Or it may be suspended from the deck. The rotor may then be lifted and secured on the special guides provided, leaving the lower part of the casing also open to inspection.

With very large turbines the cover is sometimes raised and secured to the four guide pillars, which are in this case attached to the ship's structure at their upper ends. Then, when the examination of the blading, etc., of the cover is concluded the rotor may be raised inside it and also secured.

When completely exposed the blading should be gone over very carefully, the tips of the blades being examined for indications of fouling, while particular attention should be paid to the condition of the binding wire and lacing. The engineer should look out for any bent or twisted blades and any signs of looseness. He should note the condition of the dummy rings and examine the pins of the radial dummies and of the turbine glands. He should see that the ramsbottom rings in the glands are sound and wearing well and if their lubrication appears to be sufficient.

If there is a dirty sediment in the turbine the engineer will know that water has been brought over, and all sediment must be carefully cleaned out. The rotor should be examined for any signs of pitting or corrosion, which is often the result of allowing the turbine to stand with the drains unopened. The interior of the rotor drums should also be looked to for any indication of corrosion, and may be given a coat of graphite paint. The screwed pins which secure the rotor drum to the wheels should be carefully examined for slackness. The bearings and adjusting blocks must, of course, be overhauled and the oil ways and holes cleared of any gummy deposit. Any hard places on the faces of the adjusting block may be slightly eased with a scraper, but it is scarcely likely that there will be any necessity for this.

The oil wells under the bearings should be emptied and all sediment cleaned out. The lower half of the turbine cylinder with the bearings and adjusting block, when not actually under examination, should be kept covered up and the greatest care should be taken to insure that nothing has been left in the blading before closing up again.

The most vital point in the overhauling of the turbines—the adjustment of the dummy clearance—has not been mentioned. A complete treatment of the methods to be adopted would unduly extend these notes, so that this subject would be best considered separately. Until the engineer is thoroughly familiar with the method of carrying out those adjustments he should leave the dummy clearance (if satisfactory) severely alone.

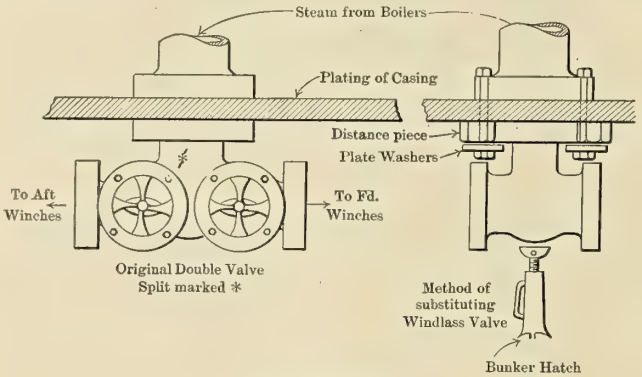
Assuming that the dummy clearance is satisfactory and that no adjustment is to be made, the adjusting nuts (which fix the fore and aft position of the adjusting-block cap) should be carefully marked before the cap is lifted, and set to the same position when reassembling. K.

### Making Use of Odds and Ends.

The following mishap and its repair, I think, tend to show marine engineers aboard tramp steamers the value of taking care of what appeared at the time to be useless articles; for it proved to me the advantage of having retained from the junk dealer an old windlass stop valve which had been knifed up, or rather the valve seat had been knifed up so often that it had become thin enough to allow the steam to pass through the somewhat porous metal of which it was made.

At the time of this accident I was chief of a fairly large tramp steamer fitted with electric lights and all the usual modern auxiliary machinery, etc. Owing to the cheap and simple steam-pipe arrangements, when steam was on the dynamo engine, steering gear, etc., it was also on the deck pipe, only being shut off by the usual valves, of which two were fitted in a box on the boiler-room casing. This valve box was joined to the plating on one side and the steam pipe from the boilers on the other side, the whole being bolted together by six ¾-inch bolts passing through two flanges and the plate between, thus making a double joint. About 2 feet from this valve box, nearer the vessel's side, was a trimming hatch to the side bunkers.

One day at sea—that is, when steam was in use in the steering engine, dynamo, etc., this valve box burst at the point shown in the sketch. Fortunately no one was in the immediate vicinity, or he would have been badly scalded. There




VALVE CONNECTION.

had been no previous sign of leakage or weakness about the valve box, but on closing the stop valve on the boiler top and examining the fracture it was found to be only about 1/32 inch thick, whereas the bottom part was nearly ⅜ inch thick, a condition of things which was probably caused by some movement of the pattern when casting the valve box.

As it was almost imperative to have steam on deck again as soon as possible, I decided not to attempt to repair the damaged casting. On looking around our storeroom I came across the old windlass stop valve, which I decided to use as a T-piece, although it was some 4 inches shorter than the original valve box. The two end flanges were already drilled to the same templet as the deck steam pipe flanges. I removed the cover and valve and valve spindle (and here I must add that the cover was flanged and not screwed, as many, especially American, valve covers are). I took out the studs and found the

diameter of the cover flange, which was such as permitted it to be placed against the plating, the holes for the bolts of the double joint being clearly outside. I then jointed the steam pipe with bolts through the original holes with plate washers on the back side, taking the flange of the old windlass stop valve and further placed our 5-ton screw jack between the flange and the above-mentioned bunker hatch. I then had to hook back one of the clips on the deck pipe and coax the pipe along in order to join up the pipes to the end flanges of our new T-piece. When this was done steam was turned on, and as the steam pipes were constructed with large expansion bends they sprang along further and I found the job to be quite safe as long as we did not ship any heavy seas. Further than this we were only a couple of hours in making the change.

As the vessel was bound to Moulmein, Burmah, and was to be there only a day or two, I had no time to get a new casting made and did not feel justified in going across the Bay of Bengal, etc., deeply laden with the job as it was. Fortunately, I was able to obtain very cheaply an old cast iron T-piece, with flanges somewhat near the required size and the proper length, the end flanges of which had already been drilled. These holes I had plugged up and fresh ones drilled as required, and I also had the side flange, which had not been drilled, drilled to suit the holes in the plating and the casing and the steam pipe to the boiler. It was a very simple job to joint this in place and all seemed well again except that we could not shut off steam from the forward and aft parts of the vessel, and, as the deck steam pipes passed very near the officers' accommodation, this was certainly no improvement from their point of view, especially in so hot a climate. It was suggested that I fit blank flanges in between the T-piece and the steam pipes. This I did not deem to be right, for in river navigation one never can tell when an anchor may have to be manipulated or some other deck order required, so the steam remained on.

This T-piece withstood the pressure of 180 pounds for some days, when I was lucky enough to observe a pin-hole "weep" in it, and we then and there removed same for further repairs and improvement which were fitted as follows, and the job then lasted until our arrival in Germany, where a new valve box was obtained, the original valves, valve spindles, glands, covers, studs, etc., being used, which considerably lessened the cost of our new outfit.

After removing the cast iron T-piece for repair the method I employed was this: I cut a piece of iron pipe the length of the casting and also drilled a large hole and cut it to suit the branch leading to the steam pipe from the boilers. As this pipe was some 3/8 inch too small in diameter, I placed it central with small pieces of wood, also placing a wood plug up the branch to the boilers. Then I melted a quantity of old white metal which we had taken out of a bottom end brass sometime previously, and ran this in around the iron pipe inside the casting; then withdrew the wood plug and rejointed the T-piece which, as I said before, proved a satisfactory repair.

Thus, in this case, the use of the old brass valve as well as the white metal shows the advisability of keeping many old things which one is tempted to dispose of, for one never knows what situation he may be forced to meet, nor how useful old odds and ends can become under certain circumstances.

ENFIELD.

### Tiller Loose on the Rudder Head.

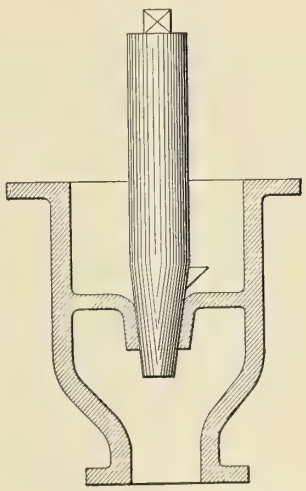
In one instance, during a voyage to the River Plate, the tiller of a vessel became loose on the rudder head and the trouble was seen to be getting worse and worse. As the effect of the looseness was to wear away the key and keyway and to grind the hole in the tiller larger and larger, it was decided to try and fix the tiller to the rudder head at sea.

The rudder was, first of all, firmly lashed and when this had been done the tiller was then taken off. Next a fire was made on the iron deck, being raised off the deck by means of firebricks and bars. The tiller head was heated in this fire to a dull red heat. In the meantime the keyway in the rudder head was made larger and a new key was made to fit, this key being, of course, of two different sizes. After this a sheet of tin was bound round the rudder head by means of copper wire, and then the heated tiller was put into place and then contracted on to the rudder head by playing a stream of water on it from a hose pipe. The new key was then driven firmly into place. This arrangement held the tiller hard and fast and made a good repair, which held out until the vessel arrived home some three months later, when a new tiller was obtained.

### Knifing Out Valve Seats in Place.

The check valves and other valves for steam and water on board ship very often give trouble, owing to the fact that some hard substance has got between the valve and its seat. This leaves a nasty hole or bend in the mitre, and it is impossible to make a tight job by simply grinding the valve in, according to the usual practice. On stopping the engines the boiler water will leak back into the hot well if the suction and delivery valves are not tightly shut down.

It is possible, however, to knife out the valve seats in place and restore them into perfect order by means of a very simple device made out of materials which can be found on board any boat. A piece of hard wood, such as a boat oar, may be taken, and by using a rough file or rasp it can be reduced in diameter



SECTION OF VALVE, SHOWING METHOD OF KNIFING.

until the wood is just a turning fit by hand in the valve seat. When this is the case, the wood should be marked off at the top of the valve seat and a small piece of sheet steel should be driven into the wood parallel with its axis at about this mark. A suitable piece of metal can be obtained by using the corner of an old firing shovel. This tool can be worked down into the valve seat. The projecting piece of steel should be made into shape, either flat or tapered, so as to suit the mitre required, this forming the knife on the top of the wood. A square head should be made, so that the mandrel thus formed can be turned round either by hand or spanner. By means of this simple tool the valve seat can be cleaned up satisfactorily. After this has been done the valve should be ground in the usual way, and it will be found that the surface will operate as well as ever.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at

17 Battery Place New York

By MARINE ENGINEERING, INCORPORATED

H. L. ALDRICH, President and Treasurer

and at

Christopher St., Finsbury Square, London, E. C.

E. J. P. BENN, Director and Publisher

HOWARD H. BROWN, Editor

AMERICAN REPRESENTATIVES

GEORGE SLATE, Vice-President

E. L. SUMNER, Secretary

Circulation Manager, H. N. Dinsmore, 83 Fowler St., Boston, Mass.
Branch Offices } Philadelphia, Machinery Dept., The Bourse, S. W. Anness.
Boston, 643 Old South Building, S. I. Carpenter.

Entered at New York Post Office as second-class matter.

Copyright 1910, by Marine Engineering, Inc., New York.

International Marine Engineering is registered in the United States Patent Office.

Copyright in Great Britain, entered at Stationers' Hall, London.

Notice to Advertisers.

*Changes to be made in copy, or in orders for advertising, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 10th of the month.*

### A Significant Change.

According to press dispatches, the Hamburg-American Liner *Deutschland* is undergoing extensive alterations and when she is again placed in commission it will be as an 18-knot cruiser instead of a 23-knot flyer. This change in the speed of the vessel means a reduction in the horsepower required for propulsion of about 50 percent and a reduction in the weight of the propelling machinery of some 3,000 tons. The *Deutschland* is the first of the crack Atlantic passenger steamships to be remodeled in this manner, and the change is significant, coming, as it does, after the remarkable performances of the latest and largest turbine-driven ships. The advent of the *Lusitania* and *Mauretania* has settled the question of the speed supremacy of the Atlantic for some time to come, and it is doubtful if any steamship company will soon have an opportunity of building fast mail ships under such advantageous terms as the Cunard Line was able to do. Extreme speed can be obtained only at a tremendous sacrifice in the earning power of the vessel, and it is only under the stimulus of large subsidies that such ships can be made to pay. Undoubtedly there are other fast ships besides the *Deutschland* which would pay larger dividends if their speed was reduced. The present tendency in the design of the Atlantic liners seems to be in the direction of large ships of moderate speed with ample cargo-carrying capacity, for there are now under construction no less than four steamships larger than the *Lusitania* and *Mauretania*, all of which are being built for moderate speeds. With the increased dimensions of these new ships speeds of 21 or 22 knots can be obtained economically, where in a smaller ship the economical speed would probably be 18 or 19 knots. During the ten years in which the *Deutschland* has been in service she has more than once held the record for the fastest passage across the Atlantic, proving a credit in every way to both her builders and owners; thus the change in her design is simply a significant indication of the modern trend of commercial steam navigation.

### Practical Operation of Steam Turbines.

Steam turbines are coming to play such an important part in the propulsion of both merchant and naval vessels that it behooves every marine engineer to master thoroughly the details of their operation and upkeep. Those who have not been so fortunate as to have an opportunity to study this problem from a practical standpoint will find much valuable information in the article on the practical operation of Parsons turbines which is contributed this month to our Department of Practical Experiences of Marine Engineers. The subject is, of course, too broad to be exhausted within the limits of a single article, but our correspondent has brought out many valuable points which should give the practical man food for thought. He points out that there is one striking difference between the reciprocating engine and the turbine which the operating engineer must bear in mind, and that is that, whereas most of the breakdowns which occur with a reciprocating engine can be repaired at sea, on the other hand a breakdown with a turbine is a more serious matter, and it is seldom that satisfactory repairs can be made at sea. Therefore, it is of the utmost importance for the man in charge of turbine engines to keep the strictest watch over the machinery and prevent as far as possible any opportunity for a breakdown to occur. The importance of preventing even the slightest breakdown with turbines is evident when it is realized that it takes at least a week, and usually from three to four weeks, to overhaul a turbine. For this reason the opening of a set of turbine machinery is carried out at much longer intervals than is usual with reciprocating engines. It is true that breakdowns are much less frequent with turbine machinery than with reciprocating engines, because the turbine is a simpler machine. But, at the same time, the turbine is a more delicate piece of machinery, and the clearances between the moving and stationary parts are so small that neglect or anything less than the most rigid care

are inexcusable. The proverbial "stitch in time" is nowhere of more importance than in the operation of marine steam turbines.

In operating turbine machinery all parts of the turbine should be warmed up evenly and thoroughly to prevent distortion; particular care should be taken to drain off all water, and when steam is admitted the valves should be opened gradually so as to prevent priming, and the lubricating system should be maintained in the most efficient condition possible, with a constant watch on the temperatures of the bearings. The efficiency of the turbine depends largely on the vacuum maintained and, therefore, the condensers and air and circulating pumps should be given most careful attention. Once under way, if no maneuvering is required, the turbines need little attention, as compared with reciprocating engines. This does not mean, however, that the strictness of the watch should be relaxed, but merely that there is less work involved in their operation.

### Naval Engineering Progress.

The Bureau of Steam Engineering of the United States Navy has been actively engaged during the last year in important investigations with a view to improving, from both an engineering and a military point of view, the efficiency and economy of present and future warships. A comprehensive résumé of this work is given in the lecture by Engineer-in-Chief Cone before the Naval War College, which is published elsewhere in this issue.

The first, and perhaps the most important, problem discussed by Rear Admiral Cone is the question of propulsion. The introduction of the steam turbine has made imperative radical changes in the design of propellers, auxiliary machinery, lubricating systems, etc., and the Navy Department is to be congratulated on its far-sighted policy in designing a sufficient number of sister ships of various types and installing upon them rival types of engines, so that comparative data regarding their performance could be obtained. The thoroughness with which this has been done has given the engineering world some invaluable information and, incidentally, has upset some popular theories regarding the comparative value of reciprocating and turbine engines. As a result of these tests, while practically every naval power is adopting without reservation the turbine for propulsion of battleships, the United States will install reciprocating engines in her latest battleship.

In the effort to improve the efficiency and economy of naval vessels certain tendencies in design can be noted along which improvement may be expected in future. Although the question of boilers seems to have been satisfactorily settled for the present, yet there is a decided tendency toward the use of small-tube express boilers, and it is quite probable that this type of boiler will play an important part in battleship design in the future. The use of oil fuel on all future United States battleships is urgently recommended. Aside from the question of the relative merits of the direct-connected reciprocating and turbine engines, the development of reduction gears for turbine drive is progressing rapidly, and either the mechanical, electrical or hydraulic gear may prove to be the means of establishing the supremacy of the turbine drive beyond a doubt. In another direction the possibility of gas propulsion is not so remote as to preclude investigation into its merits. For small powers this seems to be thoroughly practical at the present time, and, on account of the opportunities for effecting economy, it seems probable that a decided effort will be made to develop satisfactory engines and producers for large powers. For small auxiliary engines the heavy oil engine is now becoming recognized as a valuable type.

Not the least important part of the work done by the Navy Department in the last year, however, is the improvement in the economy of existing vessels. A detailed account of various ways in which economies have been effected is given in the lecture to which we have referred, and we commend this to the careful perusal of every marine engineer. The results speak for themselves.

A most important point to keep in mind in any attempt to increase the efficiency of a marine steam plant is the matter of boiler efficiency. It has been found that air leakage in boiler settings is largely responsible for poor economy in many boilers. Leakage of air immediately affects the percentage of $CO_2$ in the gases. In one instance the percentage of $CO_2$ was increased from 4 to 11 simply by carefully plugging up all the air holes that could be found in the boiler setting. As an indication of what is going on in the furnace it is advisable to fit $CO_2$ recorders to every boiler. If the $CO_2$ recorder is accurate and is properly installed, it will give a good indication of what the firemen are doing and are capable of doing, so that a check can be kept upon their work. As stated in Rear-Admiral Cone's report, the use of automatic $CO_2$ recorders showed that the boiler casings on most naval vessels leaked air, and, as a consequence, after due attention had been given to the prevention of air leakage, the result was a saving in coal which, in some cases, amounted to as much as 8 percent. On ships where Scotch boilers are fitted the question of air leakage, of course, is not so important; but the use of a $CO_2$ recorder here will give a valuable and systematic check on the work of the fireroom force, and its use should be beneficial. Another practical means of indicating boiler economy is by autographic registration of the furnace temperature. A continuous record of the furnace temperature, taken by means of a pyrometer and recording gage, can be secured with little trouble, and it will show at a glance any great drop in the economy of the boiler.

### Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

BATTLESHIPS.

| | Tons. | Knots. | | Nov. 1 | Dec. 1. |
|---|---|---|---|---|---|
| Florida .... | 20,000 | 20¾ | Navy Yard, New York..... | 80.6 | 83.7 |
| Utah ..... | 20,000 | 20¾ | New York Shipbuilding Co.. | 89.9 | 92.3 |
| Arkansas ... | 26,000 | 20½ | New York Shipbuilding Co.. | 50.1 | 52.8 |
| Wyoming .. | 26,000 | 20½ | Wm. Cramp & Sons..... | 43.3 | 46.3 |

TORPEDO-BOAT DESTROYERS.

| | | | | | |
|---|---|---|---|---|---|
| Perkins .... | 742 | 29½ | Fore River Shipbuilding Co.. | 98.1 | 100.0 |
| Sterrett ..... | 742 | 29½ | Fore River Shipbuilding Co.. | 92.5 | 99.0 |
| McCall ..... | 742 | 29½ | New York Shipbuilding Co.. | 96.0 | 96.2 |
| Burrows .... | 742 | 29½ | New York Shipbuilding Co.. | 95.1 | 96.0 |
| Warrington.. | 742 | 29½ | Wm. Cramp & Sons..... | 89.1 | 91.2 |
| Mayrant .... | 742 | 29½ | Wm. Cramp & Sons..... | 86.7 | 90.3 |
| Monaghan .. | 742 | 29½ | Newp't News Shipbuilding Co. | 46.1 | 55.5 |
| Trippe ..... | 742 | 29½ | Bath Iron Works..... | 76.0 | 81.2 |
| Walke ..... | 742 | 29½ | Fore River Shipbuilding Co.. | 66.5 | 73.2 |
| Ammen .... | 742 | 29½ | New York Shipbuilding Co.. | 76.5 | 79.9 |
| Patterson ... | 742 | 29½ | Wm. Cramp & Sons..... | 51.7 | 54.4 |

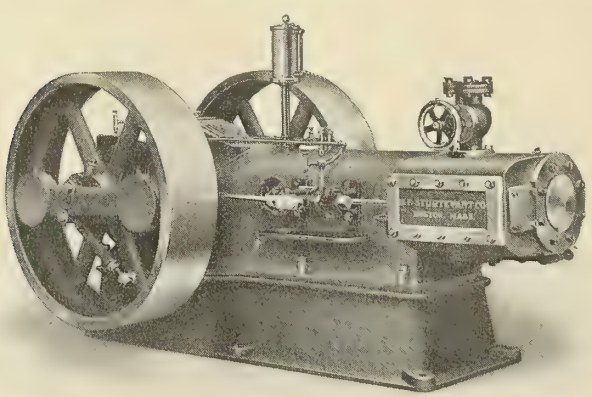
SUBMARINE TORPEDO BOATS.

| | | | | | |
|---|---|---|---|---|---|
| Seal ..... | ... | .. | Newp't News Shipbuilding Co. | 71.4 | 72.9 |
| Carp ..... | ... | .. | Union Iron Works..... | 70.0 | 74.0 |
| Barracuda .. | ... | .. | Union Iron Works..... | 71.1 | 75.0 |
| Pickerel .... | ... | .. | The Moran Co..... | 64.3 | 68.0 |
| Skate ..... | ... | .. | The Moran Co..... | 64.3 | 68.0 |
| Skipjack .... | ... | .. | Fore River Shipbuilding Co.. | 57.5 | 62.2 |
| Sturgeon ... | ... | .. | Fore River Shipbuilding Co.. | 57.8 | 64.3 |
| Tuna ..... | ... | .. | Newp't News Shipbuilding Co. | 33.9 | 46.7 |
| Thrasher ... | ... | .. | Wm. Cramp & Sons..... | 20.2 | 23.0 |

## ENGINEERING SPECIALTIES.

### Sturtevant Horizontal Engines.

The engine illustrated is of the horizontal center crank type, built by the B. F. Sturtevant Company, Hyde Park, Mass. It is designed and built for both throttling and automatic regulation, and for medium, high and low-pressures. The manufacturers claim for these engines compactness, durability, quiet and satisfactory operation. The frame is equipped with openings which render the recipocating parts easy of access, yet which may be closed, oil and dust tight by covers provided for the purpose. The cylinder is thoroughly insulated and equipped with relief valves adjustable to operate at any desired pressure. A water-shed partition prevents the passage of the oil from the frame into the cylinder, and steam from the cylinder into the frame. The linings of all bearings are Sturtevant white metal, which has proven its value for

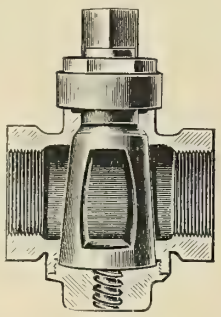


high speed work for fifty years. The main bearing combines the best points of both the two and four-part boxes, and is designed in such a manner that it is impossible for any oil to flow along the shaft. The lubrication is of the gravity type, oil supply being contained in an elevated tank of large capacity, from whence pipes convey the oil to all bearings. A Rites governor located on the fly wheel of the automatic type gives accurate speed regulation. The throttling engines may be equipped with any type of throttling governor.

The Sturtevant Company claim that in this engine they are putting the best material and workmanship obtainable, and that for all work requiring a quiet running high-speed efficient engine, for either high, medium or low pressure, this engine will meet all requirements if they are within its field.

### The Bradford Steam Cock.

The chief feature of the Bradford steam cock, manufactured by Miller, Dennis & Company, Victoria Works, Bradford, is its non-liability to jam under any conditions. This, it



is claimed, makes it especially durable. It is self-grinding, the plug being inverted and held in place by a strong spring which allows for expansion under steam pressure. These cocks are made in gunmetal and iron in all sizes, both screwed and flanged.

### The Ideal Automatic Pump Governor.

The Ideal automatic pump governor is an oil-controlled, piston actuated, pressure controlling valve for governing pumps working under a specific pressure. These governors are manufactured by the Ideal Automatic Manufacturing Company, 125 Watts street, New York City, and the Style-A governor for fuel-oil service pumps, fuel-oil supply pumps, engine-room and fire-room and bilge pumps, forced lubrication service pumps, salt-water sanitary pumps and salt-water fire pumps, is shown in Fig. 1. The valves and governor are made of the best steam bronze metal for marine purposes. No diaphragms or cup leathers are used, and the body of oil in the trap and pressure cylinder on top of the water or other liquid being pumped follows the piston in both its upward and downward strokes, thus thoroughly lubricating and protecting the wearing surface of the cylinder walls and piston from all liability to corrode and stick fast when the pump is called upon to act. It is claimed that this piston working in oil at all times makes the governor sensitive and quick acting, as the pump will start at the slightest break in the pressure.

At the bottom of the oil trap of each governor is a pet cock, so that any dirt or sediment collecting may be readily blown off without affecting the working of the valve; for this reason it is claimed that the Ideal governors are not affected by salt water or other liquids that might corrode or leave a deposit.

As the governor hangs in a perpendicular position and under the steam line, no heat reaches the working parts, consequently the heat can have no effect on the working of the governor.

Fig. 2 shows the Ideal compound-pressure pump governor Style-B. This governor has been designed for special work on the same lines as the Style-A governor, but to give a better range of pressure than is possible with a single spring operating the piston. It is applicable to most boiler feed and other pumps where varying pressures are required. By simply shifting the lever on the quadrant up or down the working pressure desired is easily obtained. If a low-pressure is needed, the

low-pressure spring is in action, and if a high-pressure is needed the high-pressure spring is brought into action by means of the lever tension on the high-pressure spring compounding or bringing into action both springs until the desired pressure to do the work is obtained.

A special feature of this style of governor is that in case of an accident to the apparatus being handled it is possible to use this device as a hand-operated stop valve by reversing the lever to an upward position on the quadrant, bringing the lever

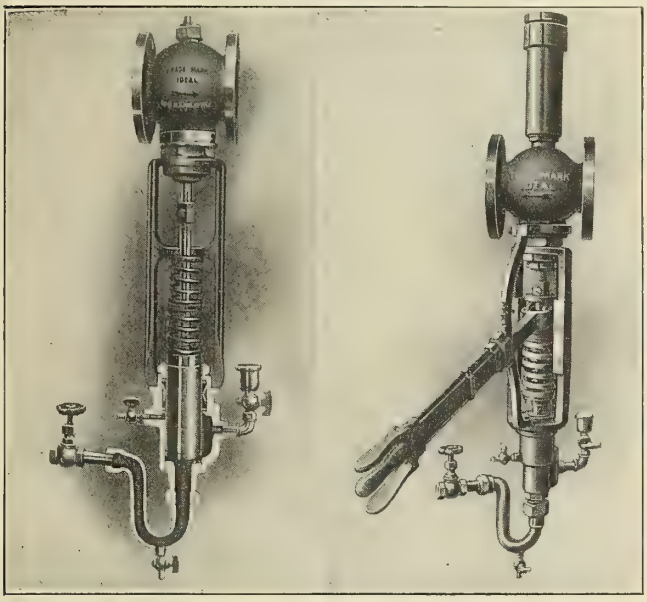


FIG. 1. FIG. 2.

in contact with the flanged nut on the valve stem proper, thus shutting the valve off tightly and stopping the pump. The pump stands in this position until the lever is shifted to the low-pressure or central position on the quadrant when the low-pressure spring is in operation, or by shifting the lever in a downward movement on the quadrant to any desired position for any intermediate-pressure by bringing into operation the high-pressure spring. This method of adjustment allows the engineer to control the pump from a low to a high-pressure, or at any intermediate-pressure which he might desire.

### The Komo Steam Trap.

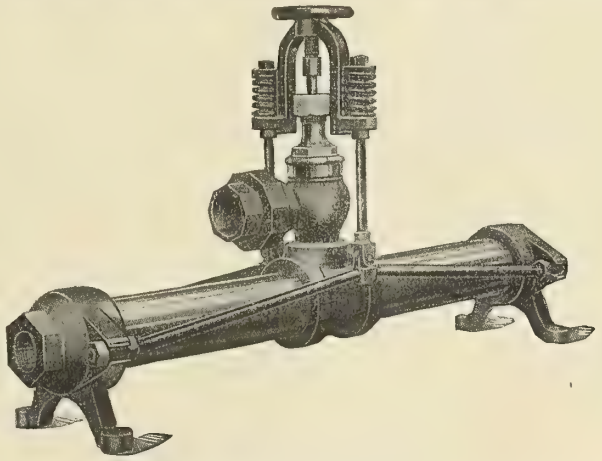
One of the principal causes of the loss of steam and fuel in operating the steam equipment of ships has been the use of steam traps which are worked by the use of a bucket, float or other internal mechanism which is constantly affected by the pitching or the rolling of the ship and which causes a trap of this type to open and blow through steam. The Komo steam trap, manufactured by the Linton Machine Co., New York, contains no complicated or internal mechanism, such as buckets, floats, tubes or diaphragms, which would be affected by the motion of the ship. It is claimed that this trap operates equally well on high or low-pressure steam, removing condensation continually and maintaining a steady steam pressure when used upon steam piping, engine cylinders, steam separators, evaporators, cooking tables, boiling kettles, heating sytems, laundry machinery, etc.

The bowed side rods, as shown in the illustration, operate the valve upon the Komo, and these bowed rods multiply the movement of the receiver tubes about 10 to 1, thus insuring a large opening of the valve port. The springs upon the upright rods combat the pressure underneath the disc and this makes a balance valve at the outlet, and allows the Komo to operate on a varying steam pressure of about 40 pounds, something which, it is claimed, no other trap operated by the expansion of metal has yet been able to do. This spring pressure follows down the loss of steam presure underneath the disc and keeps it tight to the valve seat. This is an important advantage for marine service, as the steam pressure carried, when a ship is moving, is sometimes much higher than when the steamer is at dock and when only enough steam pressure is carried to operate the auxiliaries. When adjusted, there is steam in the receiver tubes, and as soon as any condensation forms, being cooler than the steam, it causes the tubes to contract and open the valve and the trap immediately discharges the water. When the steam is shut off the system and the trap is closed the disc is at least ¼ off seat and the trap drains the system of all condensation, thus preventing the system or the trap from becoming air bound or freezing up.

The salient feature of the Komo is the large valve outlet, which, it is claimed, insures a large capacity, and it can pass through its outlet the same amount of water which could be delivered to its inlet connection. This advantage insures the free flow and instant discharge of all condensation, thus taking care of any floods or rush of water which may be delivered to the trap. No bypass is required and the trap can be cleansed of any scale or dirt by simply opening the valve and blowing out the trap thoroughly.

The yoke and adjustment can be thrown to one side, upon the hinged upright rods, so the disc may be inspected or renewed without the disconnecting of any pipe, flanges or pack joints.

As water from the steam collects, the receiving pipe cools and contracts, bringing the brackets toward each other and bending the horizontal rods so that they rise in the middle, forcing the vertical rods upwards. The lower nuts on the vertical rods then come in contact with and raise the yoke which carries the valve stem to lift the valve from its seat. The water is then forced from the receiving pipe up through the inner tube and outlet. As the water leaves the receiver, steam enters, expanding the pipe by its higher temperature, so that the brackets separate, pulling the horizontal rods



nearer a straight line and lowering the vertical rods, with their nuts, until the valve is reseated. Excessive expansion of the receiving pipe will merely cause the lower nuts on the vertical rods to be drawn further below the ends of yoke and the valve will be held to its seat by spring pressure until contraction of the receiving pipe brings the lower nuts again in contact with the ends of yoke, to raise the same, unseating the valve, as above explained.

No permanent water seal of 3 or 4 inches, which is constantly cooling and causing subsequent condensation, is required, as the valve is made with the tube which runs from the base of the valve seat too near the bottom of the receiver chamber. This tube prevents any escape of steam while the trap is in operation, as the condensation must be

forced by this tube and out the valve opening; and as the steam enters and travels along the top of the receiver tubes, heating the trap and closing it, it is prevented by this tube, which acts as a seal.

### Witting's H. B. Valves.

Fig. 1 is an illustration of a section through a Witting's patent H. B. valve (manufactured by Witting Bros., Ltd., 49 Cannon street, London, E. C.) screwed into a position that may have been originally occupied by an ordinary valve. The body is made of gun metal in one piece, the upper part *B* being continuous with the lower part *A* by six pillars or lugs between which the liquid flows. This connection, however, is not shown in the section. The working valve consists of two movable brass, phosphor bronze or steel rings made of thin sheet metal 1/32 inch to 3/32 inch thick, the outer edge of which forms a kind of bird's mouth opening all round; these,

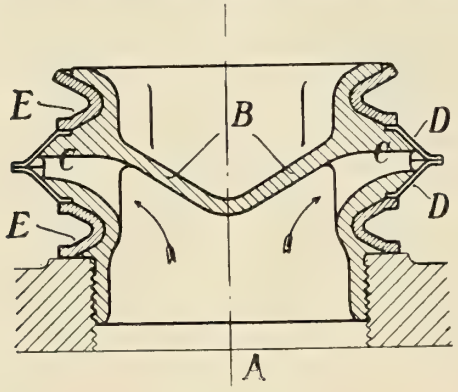



FIG. 1.

when closed, cover the annular orifice *C*. The outer edges are about 3/16 inch to ¼ inch wide, and form the valve. These rings are spun and are of great strength and resistance, and when not working the inner sides rest against the immovable body. The metal rings are kept in position and receive the necessary spring load by the V-shaped rubber rings *E*, which are sprung on and held in position by tension in the grooves in the body, and also press the metal rings against each other.

The V-shaped rubber rings form at the same time the packing between the single stages and between the valve bottom and seat ring; thus no special packings are required for multi-stage H. B. valves.

Figs. 2 and 3 are illustrations of the application of the valve in a multiple form, there being two separate valves in the one. This form can be multiplied to suit circumstances. The width of the orifice does not exceed ¼ inch; thus each lip ring moves only ⅛ inch. This very low lift, combined with

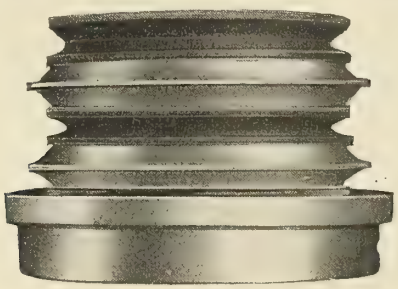


FIG. 2.

the lightness of the moving part, makes the H. B. valves particularly applicable to high-speed pumps.

Fig. 2 illustrates the valve closed, the bird's-mouth adges being closed together and held so by two rubber rings. Fig. 3 shows the open valve, both outlets being open. It is claimed these valves work equally satisfactorily, whether fixed vertically, horizontally or inclined, jamming or edging being impossible.

From careful examination and investigation of them when at work it appears that the Witting valve complies with the

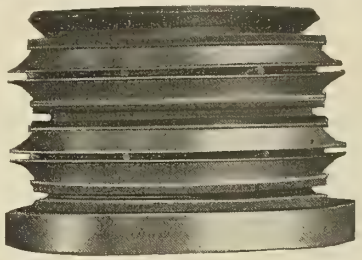


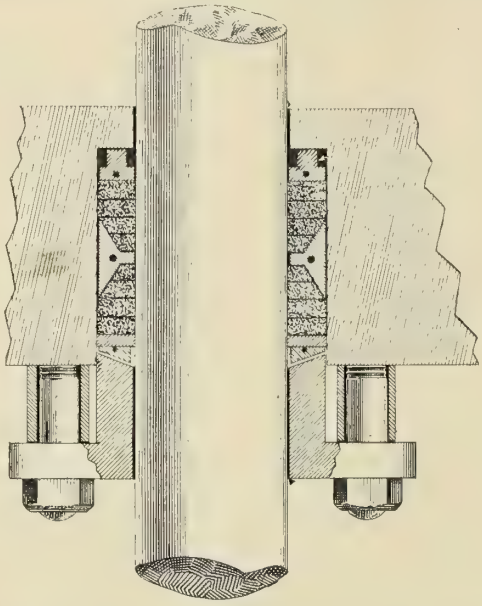
FIG. 3.

essentials of an ideal pump valve, for the reduction of noise, efficiency, durability and simple and economical renewal of parts. The working parts weigh less than a tenth part of an ordinary valve in use for similar work. The closing is prompt and uniform.

The flow of the liquid is uniform and widespread round the lips of the valve, which noiselessly close without friction. Spare valves and rings, which are the smallest and simplest parts of the mechanism, are readily and speedily substituted.

### Ideal Automatic Packing.]

The illustration shows a semi-metallic and fibrous automatic packing, designed and adapted for use on valve stems, piston rods and shafts under pressure where tight packing is necessary to prevent undue friction. This packing is manufactured with a float ring in the bottom of the box with distance lugs on it, distancing it off from the bottom of the box to form a pressure chamber. Above the float ring is a soft fibrous pack-



ing especially made for steam or gas or water, and above this the double female internally-coned ring in the center of the box, above which is again the fibrous soft packing, and above that a float ring next to the gland, performing the same operation as the float ring in the bottom of the box, holding the piston tight on both its forward and backward strokes. This packing is manufactured by the Ideal Automatic Manufacturing Company, 125 Watts street, New York City.

### Electric Safety Boiler Cleaner.

An electrically-driven tool for removing scale from steam boilers is manufactured by the Electric Safety Boiler Cleaner, Ltd., 6 Lloyds avenue, Fenchurch street, London, E. C. The apparatus is intended to supersede the old method of hand chipping, and it is not only more rapid but is apparently more efficient as regards the complete removal of scale. As can be seen from the illustration, the cleaner consists of several circular cutters about 2½ inches diameter, held in a frame on the same spindle and driven by a shaft which passes

through the handle of the apparatus and which receives its motion from a flexible shaft driven by a ½-horsepower electric motor. The number of cutters can be varied from one to three, according as the tool is to be used in confined narow spaces, or where there is plenty of room. The speed of the cutters may be varied from 1,400 to 4,000 revolutions per minute, but the usual speed is 3,000 revolutions per minute. The handle of the device may be shortened or lengthened as desired to suit the position of the different parts to be scaled, and no particular skill is required by the operator, as the cutters are merely moved over the parts to be cleaned.

## PERSONAL.

JOHN KARKLIN, formerly first assistant engineer of the steamship *City of Augusta,* has been transferred to the position of first assistant engineer of the *City of Memphis,* running between Savannah, Ga., and Boston, Mass. Harry Stewart is now chief engineer of the *City of Memphis.*

WALTER L. PIERCE, secretary and general manager of the Lidgerwood Manufacturing Company, New York, died suddenly of heart failure Dec. 10, 1910.

GEORGE SIMPSON, formerly naval architect with the Fore River Shipbuilding Company, Quincy, Mass., is now identified with the firm of John Reid & Company, naval architects and marine engineers, 17 Battery Place, New York.

PAUL E. STEVENSON, author of "A Deep Water Voyage," "By Way of Cape Horn" and the "Race for the Emperor's Cup," died suddenly of pneumonia Dec. 20 at Garden City, L. I.

### M. E. B. A. No. 33.

The annual entertainment and reception of the Marine Engineers' Beneficial Association No. 33 was held at the Lexington Avenue Opera House, New York City, on the evening of Dec. 7. The attendance was large and the entire programme a splendid success.

## COMMUNICATION.

### Information Wanted

EDITOR INTERNATIONAL MARINE ENGINEERING:

In looking over Simpson's "Naval Constructor" (Van Nostrand Company, 1904), I find on page 45 a formula (No. 14) which somewhat mystifies me. If any of your correspondents, or, perhaps, the author, could explain this it might be of interest to those who are using this book.

The formula is intended to give a vessel's beam for a certain metacentric height, when the displacement, the load draft, the coefficients of displacement, load waterline and transverse moments of inertia are given, and is as follows:

$$\text{Beam} = \sqrt{M - d\left(\frac{5\alpha - 2\delta}{6\alpha}\right) \times \frac{d}{m}}$$

where $d$ = load draft; $\alpha$ = coefficient load waterline; $\delta$ = block coefficient; $m = \frac{i}{\delta}$ ($i$ = moment of inertia coefficient).

The term $M$ is not given on page 45, but is given on page 8 as $M$ = metacenter and moment, which is somewhat indefinite.

H.

## TECHNICAL PUBLICATIONS.

**Buccaneer Ballads.** By E. H. Visiak. Size, 4 by 6¾ inches. Pages, 43. London, 1910: Elkin Matthews, Vigo street. Price, 1s. net.

This volume includes some thirty short poems, many of which have appeared in various periodicals during recent years. No more picturesque subject could be found for the exercise of poetical imagination than the old-time buccaneer. He is largely a creature of the imagination and, to many, seems more symbolical than real. Mr. Visiak's ballads, however, give true expression to the spirit of the sea, and will reach the heart of many an old sailor.

**Bureau Veritas, 1910-1911.** Forty-first year. General List of Merchant Shipping. Two volumes. Steamers: Size, 10¼ by 11 inches; pages, 1,111. Sailing vessels: Size, 10¼ by 11 inches; pages, 1,008. Paris, 8 Place de la Bourse. London, 155 Fenchurch street, E. C. Price of complete work, £3 3s. Steamers, £1 15s.; sailing vessels, £1 10s.

The general list of merchant shipping published by the Bureau Veritas is a carefully edited and conveniently arranged reference book, containing statistics not only of all important steam and sailing vessels in the world's merchant marine, but also particulars of vessels arranged according to various classifications, such as their nationality, the kind of trade in which they are engaged, etc. Lists are given of steamers and sailing vessels which have had their names changed during the past year, and also of iron and steel shipbuilders arranged according to nationality; of steamship owners, arranged according to nationality, with the names and the gross tonnages of their fleets. There are also lists of the principal dry-docks, patent slips, etc., throughout the world.

**Work, Wages and Profits.** By H. L. Gantt. Size, 5 by 7½ inches. Pages, 194. Charts, 6. New York, 1910: *The Engineering Magazine.* Price, $2.00.

The author of this book has been closely interested in advanced work in the field of labor management for more than twenty years and for more than ten years he has been prominently identified with certain methods of labor management which are becoming recognized as of the highest importance. The subject is still obscure, however, and there seems to be a woeful lack of information on the part of many works managers. To such we can highly recommend this book as

presenting the results of a most careful scientific investigation leading to certain conclusions which give bright promise for betterment in industrial conditions. The book contains nine chapters which treat of the following subjects: The application of the scientific method to the labor problem; the utilization of labor; the compensation of workmen; day work; piece work; task work with a bonus; training workmen in habits of industry and co-operation; fixing habits of industry, and profits and their influence on the cost of living.

## SELECTED MARINE PATENTS.

*The publication in this column of a patent specification does not necessarily imply editorial commendation.*

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

968,823. PROPELLING DEVICE. GEORGE WESTINGHOUSE, OF PITTSBURG, PA.

*Claim* 2.—The combination of a prime mover and a fluid pump comprising primary and secondary elements, the primary element of which is driven by the prime mover, a propeller attached directly to and driven by the secondary element of the pump, the arrangement being such that the flow of fluid through the secondary element is utilized for aiding in the propulsive effort of said propeller. Eleven claims.

971,409. PROPELLER. THEODORE ROGGENBUCK, OF SAN FRANCISCO, CAL.

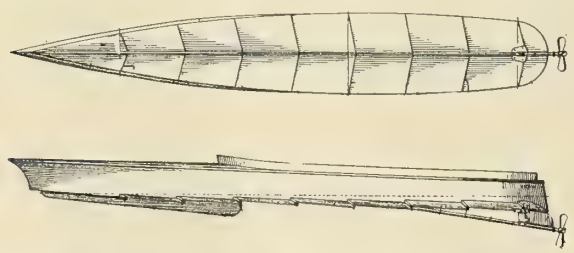
*Claim* 1.—The combination in a propeller of radial and pitched vanes, said vanes having overhanging plates at the ends with the outer edges of said plates inturned substantially toward the axis of the propeller. Four claims.

971,240. RUDDER. WILLIAM R. BENNETT, OF ST. JOHN, NEW BRUNSWICK, CANADA.

*Claim.*—A rudder comprising a post having braces and pintle knuckles integrally formed therewith, in combination with plates having their rear sections deflected outwardly, said plates being secured to said post by said braces. One claim.

971,029. HYDROPLANE BOAT. WILLIAM HENRY FAUBER, OF CHICAGO, ILL.

*Claim* 1.—A hydroplane boat provided at each side of the center line of the bottom of its hull with a series of hydroplane members which



form the flotation surface of the said bottom and are arranged in stepped relation and inclined laterally and downwardly toward the keel line of the boat. Ten claims.

970,607. PROPELLING AND DRIVING MECHANISM. JOSÉ CERVELLI, OF BUENOS AYRES, ARGENTINA, ASSIGNOR OF ONE-THIRD TO JOSÉ MOLINARI AND ONE-THIRD TO JEAN BERNASCONI, OF BUENOS AYRES, ARGENTINA.

*Claim.*—Mechanism designed to be employed for the propulsion of ships, submarines and aerostats, as well as for the production of motive power by means of a current of air or water, which mechanism comprises a rotary driving or propelling shaft, a bearing in two parts formed by the said shaft itself, a trunnion located in said bearing perpendicularly to the axis of the said shaft, blades rigidly connected to said trunnion, placed at an angle of 90 degrees to each other and provided at their bases with lateral bosses, and two stationary cam-plates arranged with relation to one another so as to form an annular guiding groove for the blades of such a form as to guide the bosses thereof in a constrained fashion on either side throughout their revolving motion, with the object of correctly and surely causing at each half revolution of the propeller shaft a movement of rotation of 90 degrees of the blade-trunnion and consequently a reversal of the position of the blades between positions which are parallel and transverse respectively to the propeller shaft. One claim.

972,180. SAFETY APPLIANCE FOR SHIPS. CONSTANTINO FUGAZZI, OF WEST PHILADELPHIA, PA.

*Claim* 1.—In a ship, the combination with a portion of the body of the ship, of a safety-appliance comprising an air-containing receptacle adapted to serve as a float or buoy, means for supporting said air-containing receptacle upon a portion of the upper and outer part of the ship, and mechanism for lowering said air-containing receptacle over the side of the ship, comprising sprocket-wheels, sprocket-chains passing over said sprocket-wheels, and flexible connections between said air-containing receptacles and said chains. Twenty claims.

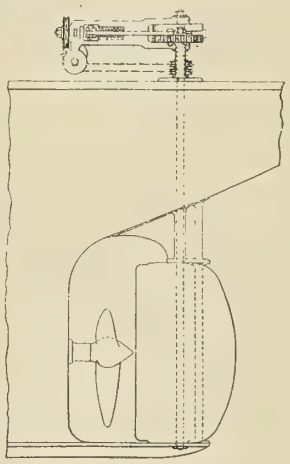
972,337. VIBRATING PROPELLER. BARTON H. COFFEY, OF BOSTON, MASS.

*Claim* 1.—A vibrating propeller consisting of mutually reacting motor-planes, each plane provided with means to oscillate it upon an axis and to hold it substantially motionless at the termination of each oscillation; the several means being so organized that there shall substantially always be planes in motion and planes at rest. Six claims.

British patents compiled by G. E. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 21 Southampton building, W. C., London.

22,021. STEERING AND CONTROLLING DEVICES FOR SCREW SHIPS. J. P. H. LUND, ROCKHAMPTON, QUEENSLAND.

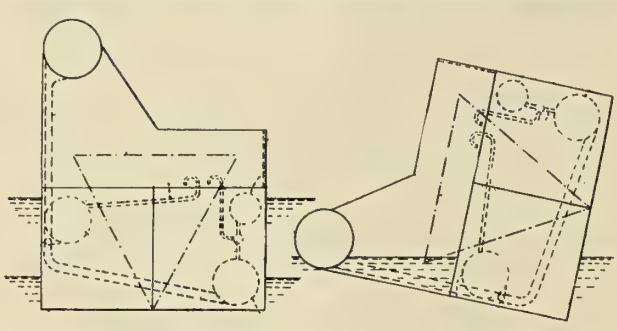
Relates to twin balanced rudders, which by this invention are adapted to be moved parallel with one another for steering purposes or to be moved symmetrically through various angles for the purpose of slowing the speed or to stop the vessel. In steering, the tiller is simply moved



about its fulcrum, then toothed segments turn pinions fixed on the rudder posts simultaneously, and the rudders are parallel in any position. In causing the rudders to act as a brake or to direct the water forward, a wheel is turned by chains passing over pulleys to turn a screw and so move a nut and connecting rods, which thus move the segments relatively to each other.

22,712. SELF-DUMPING BARGES. A. F. WIKING, STOCKHOLM, SWEDEN.

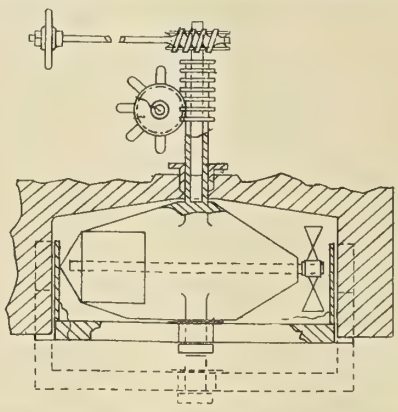
In the case of a barge, to dump the load, compressed air from 5 drives water from tank 4 through pipe 7 to tank 2 until the elevated weight causes the barge to assume, more or less, the second position



shown, in which the contents of hold 13 are discharged. Water from tank 2 is then allowed to run down into tank 3 to allow the weight of the exposed hull to right the vessel when tank 3 can be emptied back into tank 4 by gravity.

26,329. DRIVING AND STEERING VESSELS AND THE LIKE. R. C. SAYER, BRISTOL.

A propeller, with or without its motor, is mounted so that it may be turned about shaft for steering or reversing by means of a worm and



wheel. It may also be raised or lowered to increase efficiency on slides in guides by means of a hand wheel and circular teeth. The arrangement is also adapted for submarines by mounting it on half gimbal rings and a circular slide.